PB-217 049

# POLLUTION OF INTERNATIONAL BOUNDARY WATERS 1948-1949 INVESTIGATION. NIAGARA RIVER, LAKE ERIE, LAKE ONTARIO SECTION

International Joint Commission-
United States and Canada

May 1950

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# REPORT
# OF THE
# BOARD OF TECHNICAL ADVISERS
# TO THE
# INTERNATIONAL JOINT COMMISSION
# ON THE
# POLLUTION OF INTERNATIONAL BOUNDARY WATERS
# 1946 - 1949 INVESTIGATION

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## NIAGARA RIVER
## LAKE ERIE - LAKE ONTARIO SECTION

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# 1948 - 1949 INVESTIGATION

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## NIAGARA RIVER
## FROM
## LAKE ERIE TO LAKE ONTARIO

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MAY - 1950

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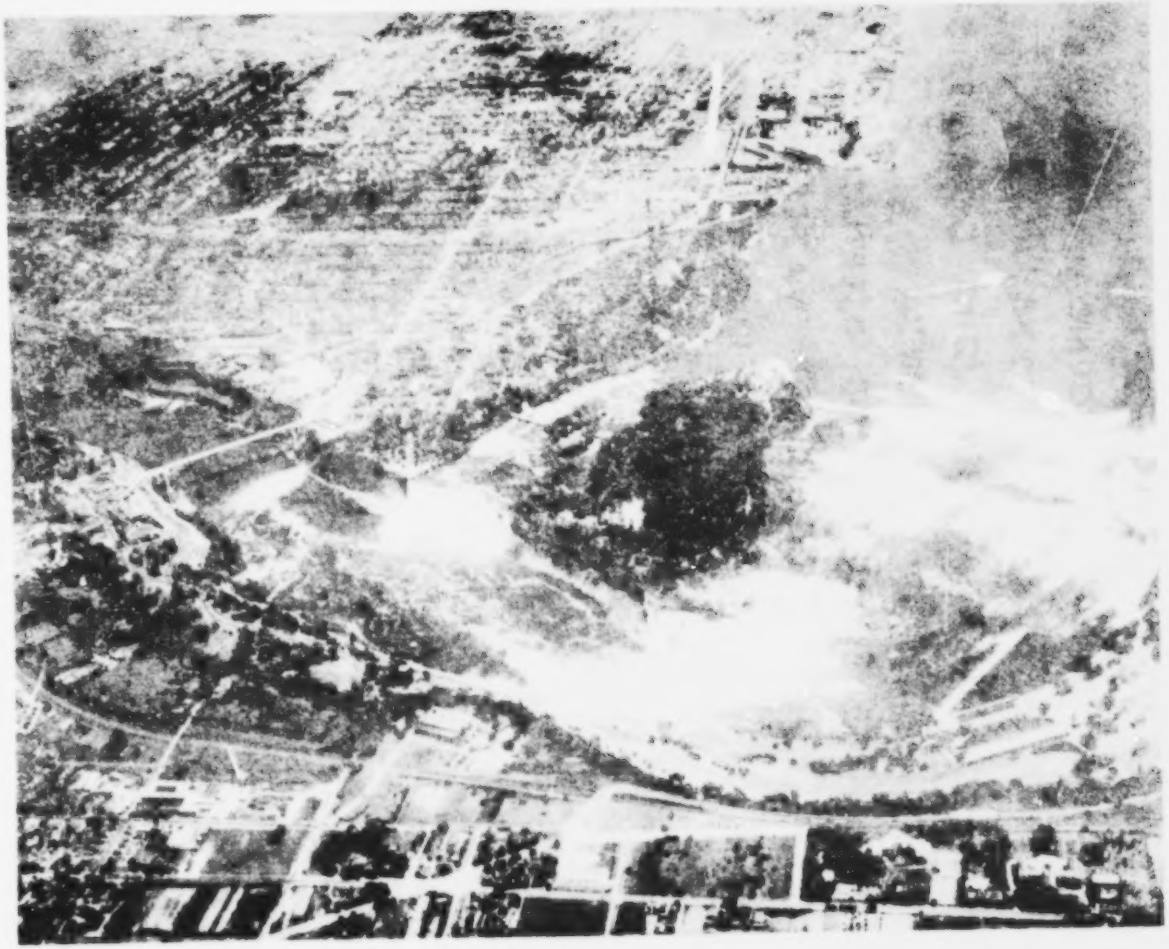

NIAGARA FALLS
The Niagara River, famed in history, is noted for scenic beauty, hydro-electric power, and industrial development.

"Under the terms of the Treaty creating this Commission, these affected waters are under the jurisdiction of the International Joint Commission, indicative of the confidence that these two great countries have in each other; there is nothing like it elsewhere in the world."

-- A. O. Stanley
Chairman, United States Section
International Joint Commission

* * * * *

"Our whole aim as an international Commission is to work out solutions to problems that are a matter of conflict, or which may become so, on both sides of the boundary. This Commission is guided by a principle which if adopted by other countries in the world would eliminate the state of fear in which they are now living. It is the best example of how difficulties between neighbouring nations with differing interests and differing peoples may be overcome."

-- J. Allison Glen
Chairman, Canadian Section
International Joint Commission

Canada
United States

UPPER NIAGARA RIVER
Looking downstream from the River inlet, showing the Peace Bridge, Black Rock Canal, and Grand Island in the middle distance.

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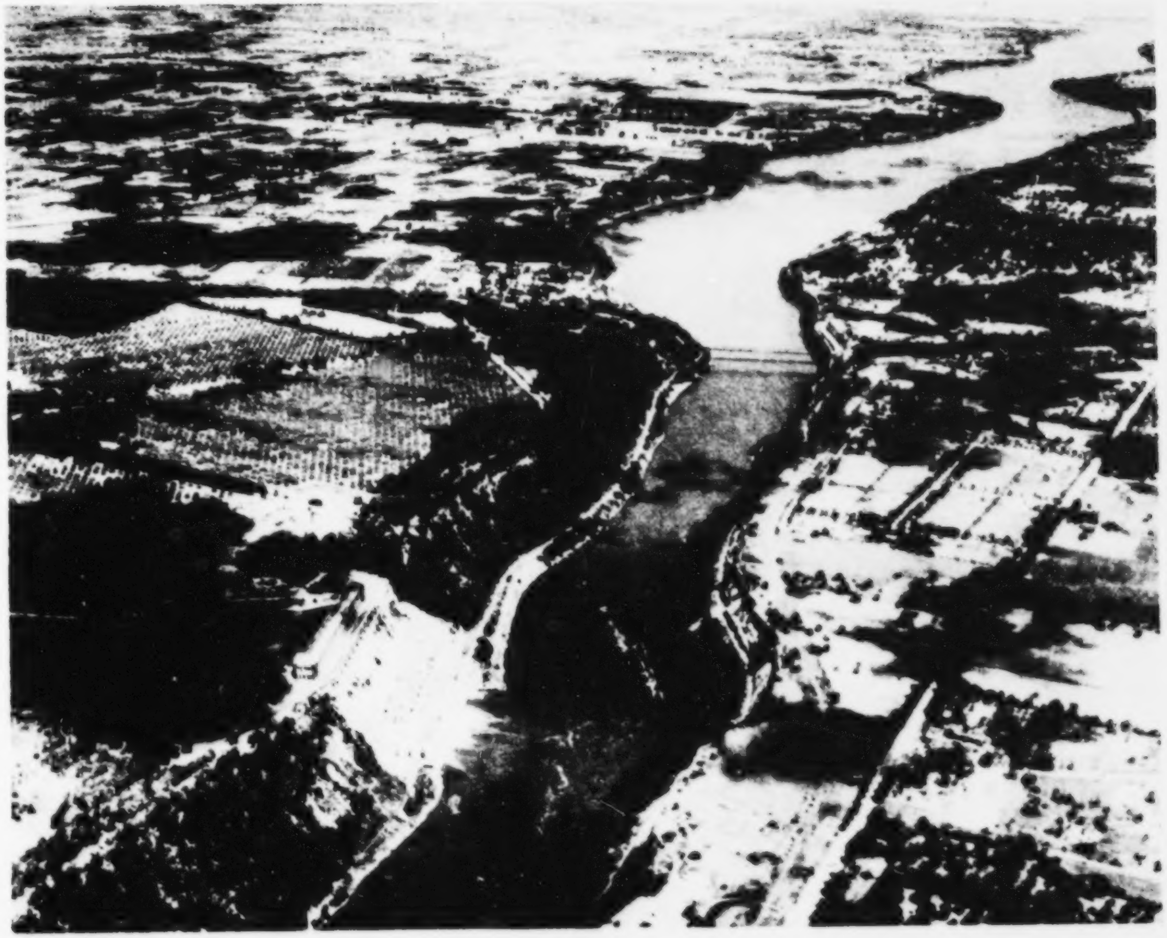
Canada
United States

LOWER NIAGARA RIVER
Looking downstream, showing the Queenston Power Plant, Lewiston Bridge and the River outlet into Lake Ontario in the distance.

## LETTER OF SUBMITTAL

To the International Joint Commission
United States and Canada

The Board of Technical Advisers submits herewith its report on pollution in that section of the International Boundary Waters covered by the amended reference to the Commission, dated April 2, 1948.

Respectfully submitted,

The Board of Technical Advisers

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| Earl Devendorf | A. E. Berry |
| Chas. R. Cox | A. V. DeLaporte |

May 1950

## ACKNOWLEDGEMENTS

Valuable assistance has been rendered, during this investigation by the various municipalities and industries as well as several State, Provincial, and Federal agencies on both sides of the boundary. Special acknowledgement is made to the following:

On the United States side to:

Buffalo Sewer Authority

City of Niagara Falls

New York State Department of Health

New York State Conservation Department

New York State Air National Guard

U. S. Coast Guard, Ninth District

U. S. Corps of Engineers, Buffalo District

U. S. Geological Survey

U. S. Lake Survey

U. S. Public Health Service, Environmental Health Center

and on the Canadian side to:

City of Niagara Falls

Ontario Department of Health

Department of Mines and Resources

Water and Power Bureau

Mines and Geology Branch

Department of National Health and Welfare

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## PERSONNEL

The personnel assigned for all or part time to conduct the field work in the 1948-1949 investigation were made available by the U. S. Public Health Service, the Department of National Health and Welfare of Canada, and the Ontario Department of Health as follows:

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Ontario Department of Health:

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Acknowledgement is made to V. G. MacKenzie, and C. C. Ruchhoft of the U. S. Public Health Service, and F. W. Gilcreas and C. C. Agar* of the New York State Department of Health, for their advice and assistance during the conduct of this investigation. Messrs. Ruchhoft, Gilcreas and DeLaporte also served on a special committee on laboratory procedures.

---

* Deceased

# DEFINITION OF TERMS

| | |
|---|---|
| B. coli or B. coli group | the coli-aerogenes group as used in all editions of Standard Methods of Water Analysis prior to the sixth edition. It is equivalent to the coliform group as defined in later editions of Standard Methods and as used during this investigation. |
| Board, Board of Sanitary Experts, or Advisory Board | Board of Technical Advisers to the International Joint Commission in the 1948-1949 investigation (referred to as the 1949 investigation). |
| B.O.D. | Biochemical Oxygen Demand. |
| Boundary waters | the waters from main shore to main shore between the United States and Canada, as defined in the Treaty of 1909. |
| °C. | Degrees Centigrade. |
| Can. | Canada |
| c.f.s. | cubic feet per second. |
| Coliform or coliform group | those organisms which will ferment lactose in the presence of brilliant green bile in the proportions contained in standard dehydrated media of that type. |
| Commission | the International Joint Commission. |
| f.p.s. | feet per second. |
| Imp. | Imperial |
| International Boundary or boundary | the boundary between the United States and Canada. |
| L.W.D. | Low Water Datum. Local water level as referred to mean tide at New York City. |
| median | the value which is equaled or exceeded by exactly half the values in the given list. |
| M.G.D. | million gallons per day. |

| | |
|---|---|
| ml. | milliliters |
| M.P.N. or M.P.N. Index | the number of coliform organisms per 100 ml. when calculated from multiple tube dilution tests. |
| No. | number |
| pH | hydrogen ion concentration. |
| Phelps Index | the number of B. coli per 100 ml. when calculated from the results of single tube dilution tests. |
| p.p.b. | parts per billion, by weight. |
| p.p.m. | parts per million, by weight. |
| primary treatment | the first major step in a sewage treatment works, usually screening, grit removal, and sedimentation. |
| secondary treatment | the treatment of sewage by biological methods following primary treatment. |
| Section | the Lake Erie-Lake Ontario Section of the boundary waters. |
| seiche | an oscillation of the surface of a lake due to meteorological conditions, with the period of a cycle varying from a few minutes to many hours. |
| slug or spill | the release of a volume of highly concentrated polluting material over a short period of time. |
| U. S. | United States |
| % | percent |

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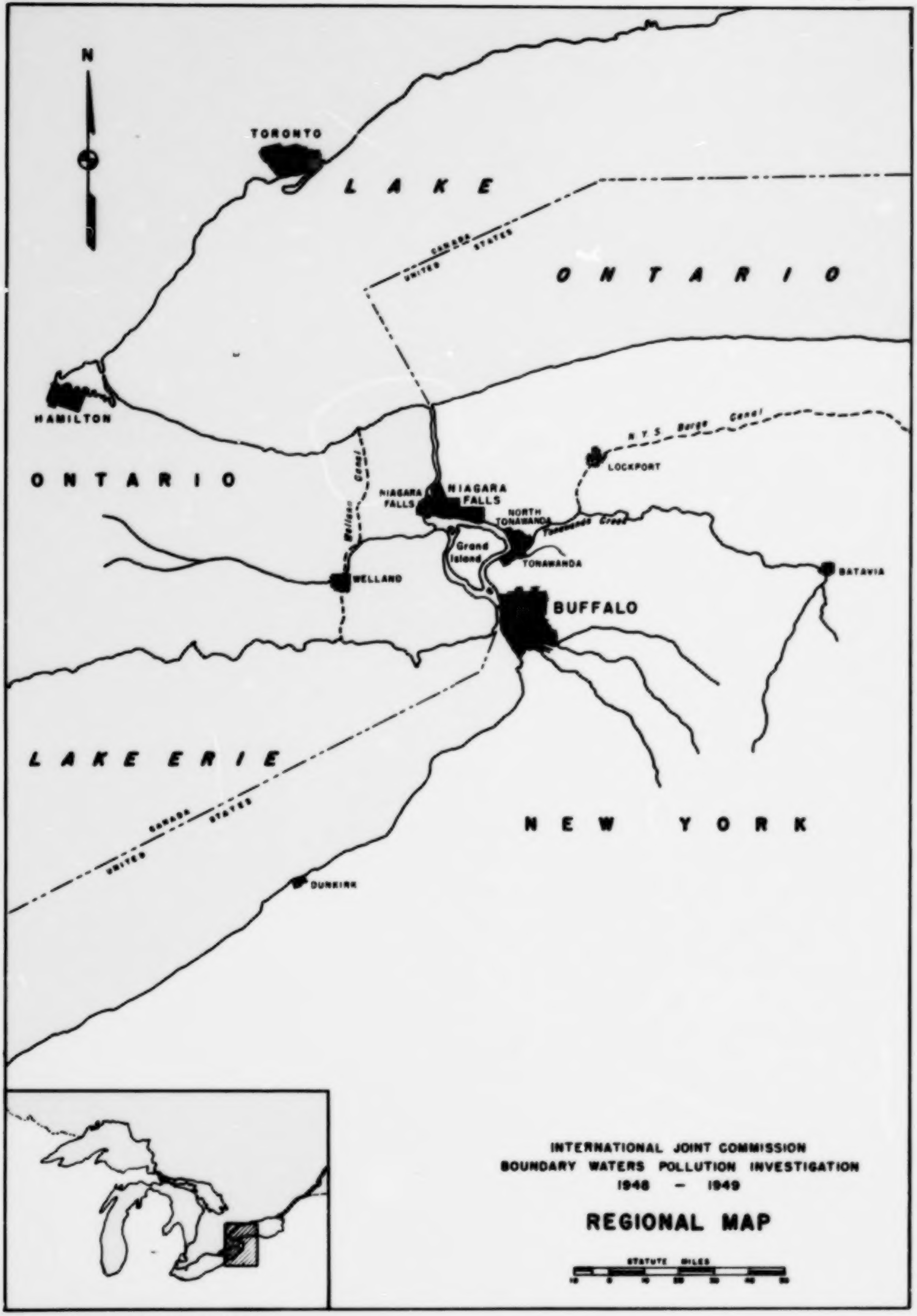
N
TORONTO
LAKE ONTARIO
CANADA
UNITED STATES
HAMILTON
ONTARIO
Welland Canal
NIAGARA FALLS
NIAGARA FALLS
N Y S Barge Canal
LOCKPORT
NORTH TONAWANDA
Tonawanda Creek
Grand Island
TONAWANDA
WELLAND
BUFFALO
BATAVIA
LAKE ERIE
CANADA
UNITED STATES
NEW YORK
DUNKIRK
STATUTE MILES
10
0
10
20
30
40
50

INTERNATIONAL JOINT COMMISSION
BOUNDARY WATERS POLLUTION INVESTIGATION
1948 – 1949

## REGIONAL MAP

Army U.S. Lake Survey Detroit Litho 1950 100

# CHAPTER I

# FINDINGS AND RECOMMENDATIONS

"Nothing is difficult;
it is only we who are indolent."

- B. R. Haydon

This investigation of pollution of the boundary waters in the Lake Erie-Lake Ontario Section extended from July 1948 to November 1949. A comprehensive examination has been made of all types of pollution. Additional information has been secured from a number of sources. A detailed study of these data has enabled the Board of Technical Advisers to reach conclusions on the questions contained in the terms of reference to the International Joint Commission by the Governments of the two countries.

This investigation was carried on following the 1948 study of pollution in the Lake Huron-Lake Erie and the Lake Superior-Lake Huron Sections. The first investigation of boundary waters was made in 1913 when bacteriological tests were the primary means of measuring pollution. In the intervening 36 years, tremendous changes in the Niagara area have taken place. These have had a strong influence on the numerous uses which these boundary waters have been called upon to serve. Greater emphasis has been placed on those conditions which promote healthful living, commerce, and recreation on both sides of the boundary. All these requirements have directed public attention to the need for clean waters and to the problem of reaching that objective. This investigation has called for the application of entirely new methods to those used in 1913. These have been developed to measure the effects of concentration of population and the operation of many and varied industrial plants. Remedial measures call for restoration of the waters to suitable quality.

The investigation has enabled the Board of Technical Advisers to reach certain conclusions on the findings and to offer recommendations to the Commission for remedial measures. The findings of the Board are discussed in chapter IX and are summarized herewith.

FINDINGS

1. These boundary waters are seriously polluted from Lake Erie to Lake Ontario. The most serious pollution exists along the United States side of Lake Erie and the upper Niagara River, and due to stratification of the flowing water, is confined largely to zones paralleling the shore. This phenomenon disappears as the water passes over the Falls and through the rapids, thereby diluting and mixing wastes throughout the total volume of water.

2. The westerly part of the upper Niagara River was found to be of good sanitary quality. This water flows directly from the central part of Lake Erie.

3. There is a transfer of pollution from each side of the boundary to the other, especially pronounced in the lower Niagara River. This has been demonstrated by float studies, by visual observations, by analytical results, and by discharges of specific substances.

4. There has been injury to health and property on both sides of the boundary. This has been manifested in the following ways:

a. Health - A potential menace is present where waters polluted to the extent of these are used for domestic purposes. They are in such condition that they cannot be safely used as a potable supply without complete and continuously effective treatment. Much of the threat to health arises from such factors as bacterial overloading beyond the safe limits of water purification processes; sudden variations in pollution with accompanying erratic chlorine demand; interference of certain types of pollution with disinfectants which destroy their germicidal properties; and the probability of certain infections being carried through a water treatment process, especially if there is any interruption or breakdown in a part of that process. This situation occurred in Niagara Falls, New York, in 1933 when approximately 10,000 cases of gastroenteritis were reported among the water consumers.

These waters are so polluted in many areas as to render them unsafe for bathing purposes.

The sewage pollution present in these boundary waters must be considered as an actual and potential health hazard, whether it be through public water supplies, bathing beaches, or other vectors.

b. Property - Injury to property has been illustrated in the cost of extending water intakes and for water treatment, both for municipalities and industries; in economic loss to owners of bathing beaches and other waterfront property; in damage to watercraft; and in destruction of fish and wildlife.

c. Industry - There is evidence that these waters are polluted to such a degree as to affect their use in certain industries. An economic loss to the community, and to industry as well, will occur when a plant is unable to expand or to locate in an area because of inability to secure a satisfactory water supply.

5. Pollution of these boundary waters increased markedly from 1913 to 1936 due to a steady growth in population and major industrial expansion. Since 1936 substantial progress has been made in the control or elimination of pollution. Both municipalities and industries have contributed to this activity.

6. Public hearings held by the Commission revealed a common acceptance on the part of municipal officials and industrial management of the presence of serious pollution in these waters and the need for correction. The hearings also substantiated the findings of the Advisory Board that there was injury to health and property and interference with the various water uses on both sides of the boundary. Financing of the necessary remedial works was asserted by municipal officials to be the principal obstacle to correction.

7. Municipalities along the upper Niagara River have shown an interest in extending their water intakes beyond the zone of pollution along the United States shore.

8. Dredging in the interior of Strawberry Island under the conditions specified in the permit issued by the Corps of Engineers, U. S. Department of the Army, dated May 5, 1947, will not change the hydraulic regimen or currents in the Niagara River.

9. The frequent slug-type releases of pollution into the Upper Niagara River, particularly from the Buffalo River and harbor area, are of serious import. These are due to changing meteorological conditions and oscillations in lake level.

10. The condition of these waters requires that remedial measures be undertaken as early as possible.

RECOMMENDATIONS

The Board of Technical Advisers recommends to the Commission that:

1. Remedial measures for the abatement and control of pollution in the Lake Erie-Lake Ontario Section of the boundary waters be undertaken at the earliest possible date. These measures should be sufficient to restore and protect the uses of these waters to which the people of both countries are rightfully entitled. Major consideration should be given to uses for domestic and industrial water supplies, recreation, fish and wildlife, sanitary purposes, navigation and power.

2. The "Objectives for Boundary Waters Quality Control," prescribed in this report, be recognized in the development of remedial and preventive measures by municipalities and industry. These objectives should apply to both existing and new sources of wastes.

3. Treatment of municipal wastes by effective sedimentation and disinfection of the effluent be undertaken by all communities, and that a median coliform M.P.N. value not exceeding 2,400 per 100 ml., as set forth in the "Objectives for Boundary Waters Quality Control" at any point in these waters, following initial dilution of waste discharges, be considered as the objective for bacterial control

to attain reasonable stream sanitation. It is recognized that local conditions, on either side of the boundary, may give additional emphasis to a need for higher degree of treatment. Major population growth or industrial expansion may precipitate conditions in the future which will materially alter the requirements of treatment necessary to meet the Objectives. The estimated cost for installation of intercepting sewers and primary treatment works for municipalities in this section is $9,500,000, of which $7,250,000 is for United States and $2,250,000 for Canadian communities. These works must be financed through public funds.

4. Every effort be made to maintain the high natural quality of the water in those parts of the upper Niagara River not now polluted. Since this water should continue to be of higher quality irrespective of the degree of treatment of sewage and industrial wastes, municipalities should endeavor to extend their water intakes into this water and beyond the zone of pollution along the easterly shore.

5. Overflows from combined sewers during storm periods be treated by sedimentation and disinfection or by other methods where necessary to protect these waters for the purposes for which they are or may be utilized.

6. Industrial wastes be treated to comply, as soon as possible, with the "Objectives for Boundary Waters Quality Control." The total estimated cost for industrial waste treatment works is $9,600,000. The cost on the United States side is $9,500,000, including the Lake Erie Cooling Water Project, and on the Canadian side it is $100,000. The problem of industrial waste disposal is the responsibility

of industry.

7. The Buffalo River pollution abatement program including the Lake Erie Cooling Water Project be encouraged as an aid in further protecting the quality of the boundary waters.

8. Slugs and spills of objectionable wastes from industrial plants be avoided. Retention tanks or lagoons with provision for equalizing rates of discharge be utilized where slugs and spills cannot otherwise be controlled.

9. Sewage from vessels equipped with flush toilets and from craft used for living purposes be controlled by the installation of holding tanks, and that the tanks be emptied either by transfer of the contents to shore treatment facilities or disinfected and dumped overboard in nonrestricted areas. No garbage or other refuse be discharged overboard into these waters.

10. Materials from dredging operations be dumped only at locations where they will not interfere with legitimate water uses.

11. Definite plans for financing remedial municipal works be formulated. In this, there should be cooperation between the Commission and Federal, State, Provincial, and municipal governments.

12. Dams, canals, channels, power diversions, and other hydraulic structures on these waters, be planned with due consideration to their possible effects on water pollution.

13. Continuing contact with pollution control progress be maintained through a technical committee or board, having representation from both countries.

14. The Commission take such measures as may be legally available to it to have the pollution abatement and prevention program herein outlined initiated, promoted, and effectively prosecuted.

# CHAPTER II

# INITIATION OF THE INVESTIGATION

"I would live to study and not study to live."

- Francis Bacon, Letter to
King James The First

## THE POLLUTION PROBLEM

The waters between the United States and Canada comprise the largest body of fresh water in the world. They are vitally important to health, recreation and the national economy of both countries. Large populations and great industries have developed along the shores of these watercourses, attracted by natural water resources so essential for domestic and industrial water supplies, recreation, the reception of wastes, and for transportation and power. The success of these developments, and indirectly, of larger areas of both countries, is influenced in no small measure by maintenance of these waters free from objectionable pollution.

Pollution control is a world-wide and an ever-changing problem, intensified in those watercourses subject to a variety of riparian activities. Domestic sewage was at one time the major source of contamination, and the degree of bacterial pollution was the primary concern. This continues to be an important health problem, but industrial developments on both sides of the boundary have added new and complex factors. Wastes from industry produce effects additional to and different from those created by sewage. All or any of these industrial wastes may have a deleterious effect on the aesthetic qualities of the waters as well as on their physical and chemical properties. Their health significance is secondary to that of sewage, but they may seriously impair the use of water for domestic,

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recreational, industrial, and other purposes. The development of new products, the expansion of industrial activity, and modifications of industrial processes all may cause alterations in wastes which intensify the problems of water pollution control. This is further aggravated by the present day demand for the widest and fullest use of these waters by populations adjacent to the boundary.

## THE PREVIOUS INVESTIGATION

The pollution of boundary waters between the United States and Canada has been of concern to both countries for more than forty years. Interest has been manifest in the extent, nature, and dispersion of pollution from one side of the boundary to the other. A solution to this problem was first attempted in a comprehensive survey of these waters undertaken in 1913 by the International Joint Commission. The "Progress Report of the International Joint Commission," dated January 16, 1914, showed clearly the extent of bacterial pollution at that time. The "Report of the Consulting Sanitary Engineer upon Remedial Measures," dated March 8, 1916, recommended procedures for abating this pollution.

In the interval between 1913 and 1948, some sewage treatment plants were constructed in the Niagara River area. However, much work remained to complete the recommendations contained in the "Final Report of the International Joint Commission on the Pollution of Boundary Waters Reference" dated 1918. During this same 35 year period, important changes took place on the Niagara Frontier. Major industrial expansion accompanied by a rapid increase in population contributed adversely to the pollution problem. Dredging operations on Strawberry Island in the upper Niagara River were resumed in 1947. This created an interest in the possible effect on river currents with consequent dispersion of polluted water. This concern, combined with the increase in population and industrial development, precipitated a request for a further study of these boundary waters.

## AUTHORIZATION OF SURVEY

The Governments of the United States and Canada in April 1946 requested the International Joint Commission to investigate pollution of the boundary waters from Lake Superior to Lake Erie with respect to treaty obligations. The original terms of reference of the two Governments were amended April 2, 1948 to include the Lake Erie - Lake Ontario Section as follows:

> "I have the honour to advise you that the Governments of the United States and Canada have been informed that the waters of the Niagara River from Lake Erie to Lake Ontario are being polluted by sewage and industrial wastes emptied into these waters. Having in mind the provisions of Article IV of the Boundary Waters Treaty signed January 11, 1909, that boundary waters and waters flowing across the boundary shall not be polluted on either side to the injury of health or property on the other side, and the two Governments have agreed upon a joint Reference of the matter to the International Joint Commission, pursuant to the provisions of Article IX of said Treaty. The Commission is requested to inquire into and to report to the two Governments upon the following questions:
>
> (1) Are the waters referred to in the preceding paragraph, or any of them, actually being polluted on either side of the boundary to the injury of health or property on the other side of the boundary?
>
> (2) If the foregoing question is answered in the affirmative, to what extent, by what causes, and in what localities is such pollution taking place?
>
> (3) If the Commission should find that pollution of the character just referred to is taking place, what measures for remedying the situation would, in its judgement, be most practicable from the economic, sanitary and other points of view?
>
> (4) If the Commission should find that the construction or maintenance of remedial or preventative works is necessary to render the waters sanitary and suitable for domestic and other uses, it should indicate the nature, location and extent of such works, and the probable cost thereof, and by whom and in what proportions such cost should be borne.

"For the purpose of assisting the Commission in making the investigation and recommendations provided for in this Reference, the two Governments will, upon request, make available to the Commission the service of engineers and other specifically qualified personnel of their Governmental agencies, and such information and technical data as may have been acquired by them during the course of the investigation.

"The Commission should submit its report and recommendations to the two Governments as soon as practicable."

## BOARD OF TECHNICAL ADVISERS

In accordance with the terms of reference, the International Joint Commission appointed a board of sanitary experts to act as technical advisers to the Commission. The Board consisted of eight members, two from the Federal services of the United States, two from the Federal services of Canada, two from State services of New York, and two from the Provincial services of Ontario.

The members of the Board were:

For the United States

L.M. Fisher, Sanitary Engineer Director, U. S. Public Health Service, Washington, D. C. Later succeeded by L. F. Warrick, Senior Sanitary Engineer, U. S. Public Health Service

M. LeBosquet, Jr., Sanitary Engineer Director, U. S. Public Health Service, Cincinnati, Ohio

For Canada

J. Moss Menzies, Chief, Public Health Engineering Division, Department of National Health and Welfare, Ottawa, Ontario

W. R. Edmonds, Senior Sanitary Engineer, Public Health Engineering Division, Department of National Health and Welfare, Ottawa, Ontario

For New York

Earl Devendorf, Director, Bureau of Environmental Sanitation, New York State Department of Health, Albany, New York

C. R. Cox, Chief, Water Supply Section, Bureau of Environmental Sanitation, New York State Department of Health, Albany, New York

For Ontario

A. E. Berry, Director, Division of Sanitary Engineering, Ontario Department of Health, Toronto, Ontario

A. V. DeLaporte, Chemical Engineer, in charge of Experimental Station, Ontario Department of Health, Toronto, Ontario

The joint chairmen of the Board of Technical Advisers were L. M. Fisher (later L. F. Warrick), whose duty it was to preside over meetings of the Board in the United States, and J. Ross Menzies, who presided over meetings in Canada. The two chairmen also acted jointly as liaison officers between the Board and the Commission.

A subcommittee to aid the Board of Technical Advisers, in a study of the effect on the Niagara River of dredging on Strawberry Island, was also appointed by the Commission. Colonel Herbert D. Vogel, U. S. Corps of Engineers, District Engineer, Buffalo, New York, and Mr. C. G. Cline, Senior Assistant Engineer, Water & Power Bureau, Department of Mines and Resources of Canada, Niagara Falls, Ontario, served on this subcommittee.

The Board of Technical Advisers was given the authority to enlist the cooperation of technical officers of other Federal, Provincial, or State Departments or agencies in the United States and Canada; to employ such technical and clerical assistance, to acquire such equipment, and to make such expenditures for travel, as were found necessary.

## ORGANIZATION FOR LAKE ERIE-LAKE ONTARIO INVESTIGATION

Field work on the survey of the Lake Erie-Lake Ontario section of the boundary waters was initiated in July, 1948. The personnel for this study was supplied by the U. S. Public Health Service, the Department of National Health and Welfare, the New York State Department of Health and the Ontario Department of Health. The field work on the United States side was under the direction of Hayse H. Black, later succeeded by Roscoe H. Goeke, both

Sanitary Engineers of the U. S. Public Health Service, and on the Canadian side under A. V. DeLaporte.

### General Procedure

The Board of Technical Advisers organized the field work, assigning it to the United States and the Canadian field staffs. Each field staff undertook to examine the boundary waters and to further determine the sources and extent of pollution on its own side. Laboratories were established in St. Catharines, Ontario, and Fort Niagara, New York. The field laboratory at Fort Niagara was subsequently moved to Niagara Falls, New York. The laboratories of the Ontario Department of Health at Toronto, Ontario, the New York State Department of Health at Albany, New York, and the U. S. Public Health Service at Cincinnati, Ohio were utilized for certain examinations in connection with industrial waste surveys. Field studies included sampling of the boundary waters and tributaries, float tests for direction of currents, visual examination of the waters, and investigation of industries and other sources of pollution.

### Selection and Designation of Sampling Points

Sampling points for this investigation were selected with due regard to such factors as the location of known pollution sources, the characteristics of the stream flows, and the location of points used during the 1913 survey. These known pollution sources included municipal and industrial sewer outlets along the shores of these waters and tributary streams. Stream flow characteristics were considered significant in that they tend to influence the dispersion of pollution throughout these boundary waters. Since comparison of results with those of the 1913 survey was desired, several of the original sampling ranges were again used.

A mileage index system was used in the present investigation to identify the location of sampling ranges, municipal water intakes, and other important points on the river and its tributaries. This system involved the use of one or more letters to identify the stream or streams, followed by a number which represented the distance in river miles from the mouth or other reference point. The zero mileage point for the Niagara River was taken one mile from the mouth of the river in Lake Ontario at a bell buoy (B-1) established by the U. S. Coast Guard. Distances from this zero point were measured via the East Channel around Grand Island. On the tributaries, the letter Ni, designating the main stream, was retained and another letter or letters added to designate a specific tributary. The mileage index figures used on the tributaries represent the distance from the same zero reference point as used on the Niagara River.

The letters used in designating the various streams, with the distances above the zero reference point are given in table 1.

Table 1 TRIBUTARY DESIGNATIONS WITH MILEAGES FROM ZERO REFERENCE POINT

| Watercourse | Designation | Mileage at Mouth from Zero Reference |
|---|---|---|
| Lower Niagara River | Ni | |
| Power Canal | Ni PC | 9.0 |
| Whitty's Creek | Ni Wt | 11.4 |
| Upper Niagara River | Ni | |
| Cayuga Creek | Ni Ca | 21.0 |
| Black Creek | Ni Bl | 24.3 |
| Tonawanda Creek | Ni To | 26.4 |
| Ellicott Creek | Ni To Et | 26.5 |
| Two Mile Creek | Ni TM | 27.2 |
| Frenchmans Creek | Ni Fr | 32.8 |
| Black Rock Canal | Ni BR | 34.0 |
| Buffalo River | Ni Bu | 37.8 |
| Cazenovia Creek | Ni Bu Cz | 43.4 |

The river mileage index system was not adaptable for lake sampling points. On Lake Ontario, a system of radial ranges was used with the reference point located at the same bell buoy, B-1, as used for the river mileages. Two sampling ranges were established in Lake Erie extending from the United States to Canada. Short ranges were given letter designations and were established parallel with or normal to shore.

### Laboratory Determinations on River and Lake Samples

Routine determinations included coliforms, phenols, chlorides, ammonia, chlorine demand, hydrogen ion concentration (pH), alkalinity, turbidity, temperature, dissolved oxygen, and biochemical oxygen demand. Additional tests were made when abnormal conditions of the river were noted, and when special studies were being conducted.

In general, the analytical procedures followed were those contained in "Standard Methods for Water Analysis", 9th Edition. Specific techniques were utilized where an accepted method was not available, where the standard test for a specific compound was not sensitive enough for the high dilutions encountered, or where other substances caused interference. Such special procedures were used for oils, phenols, cyanides, and tastes, and were the same as those developed for the Lake Superior-Lake Erie investigations.

Possible variations in techniques between the laboratories of the two field staffs were minimized. The same specific batches of laboratory media were used for all bacteriological tests conducted in both laboratories. Checks on analytical procedures were made by occasionally dividing samples between laboratories.

The number of lake and river samples collected totaled 7,778, on which 27,593 examinations were made during this investigation as presented in table 2. These figures do not include analytical work associated with municipal and industrial plants.

Table 2 LAKE AND RIVER SAMPLES COLLECTED AND ANALYSES MADE

| Area or Source | Bacteriological Examinations | Plankton Determinations | Chemical Examinations | |
|---|---|---|---|---|
| | | | Samples | Determinations |
| Lake Ontario | 780 | 2 | 380 | 2,915 |
| Lower Niagara River | 656 | 13 | 496 | 3,318 |
| Upper Niagara River | 1,931 | 67 | 1,559 | 10,272 |
| Lake Erie | 621 | 2 | 512 | 3,907 |
| Tributaries | 413 | 14 | 332 | 2,682 |
| TOTALS | 4,401 | 98 | 3,279 | 23,094 |

# CHAPTER III

## GENERAL DESCRIPTION

> "A river is the coziest of friends; you must love it and live with it before you can know it."
>
> - C. W. Curtiss, Lotus Eating

The Lake Erie-Lake Ontario Section comprises the eastern end of Lake Erie, the Niagara River with its tributaries, and a portion of Lake Ontario in the vicinity of the outlet of the Niagara River. The land drained by this Section has an area of about 1,836 square miles or 0.62 % of the total drainage area of the Great Lakes System. The area under investigation is shown in figure 1. Physical characteristics and other features are described herein.

### LAKE ERIE -- EAST END

That portion of the east end of Lake Erie which is included in the Lake Erie-Lake Ontario Section embraces an area within a radius of about 10 miles from Buffalo. Lake Erie is a relatively shallow basin, with a mean depth of 90 feet. The 30-foot contour is uniformly about a mile offshore. The lake bottom, on both the United States and Canadian sides, gently slopes with a maximum depth of 60 feet in the 10-mile radius under study. Two small tributaries on the United States side empty into Lake Erie: Smokes Creek, with a tributary area of 33 square miles, and Rush Creek, with a drainage area of 11 square miles. The Canadian side has two small streams, with a drainage area of 18 square miles, that enter the eastern end of the lake.

Lake Erie is the most tempestuous of the Great Lakes because of its position in relation to storm tracks, and its shallow depth. It is subject to sudden storms which cause the lake level to fluctuate widely. At Buffalo,

18-A

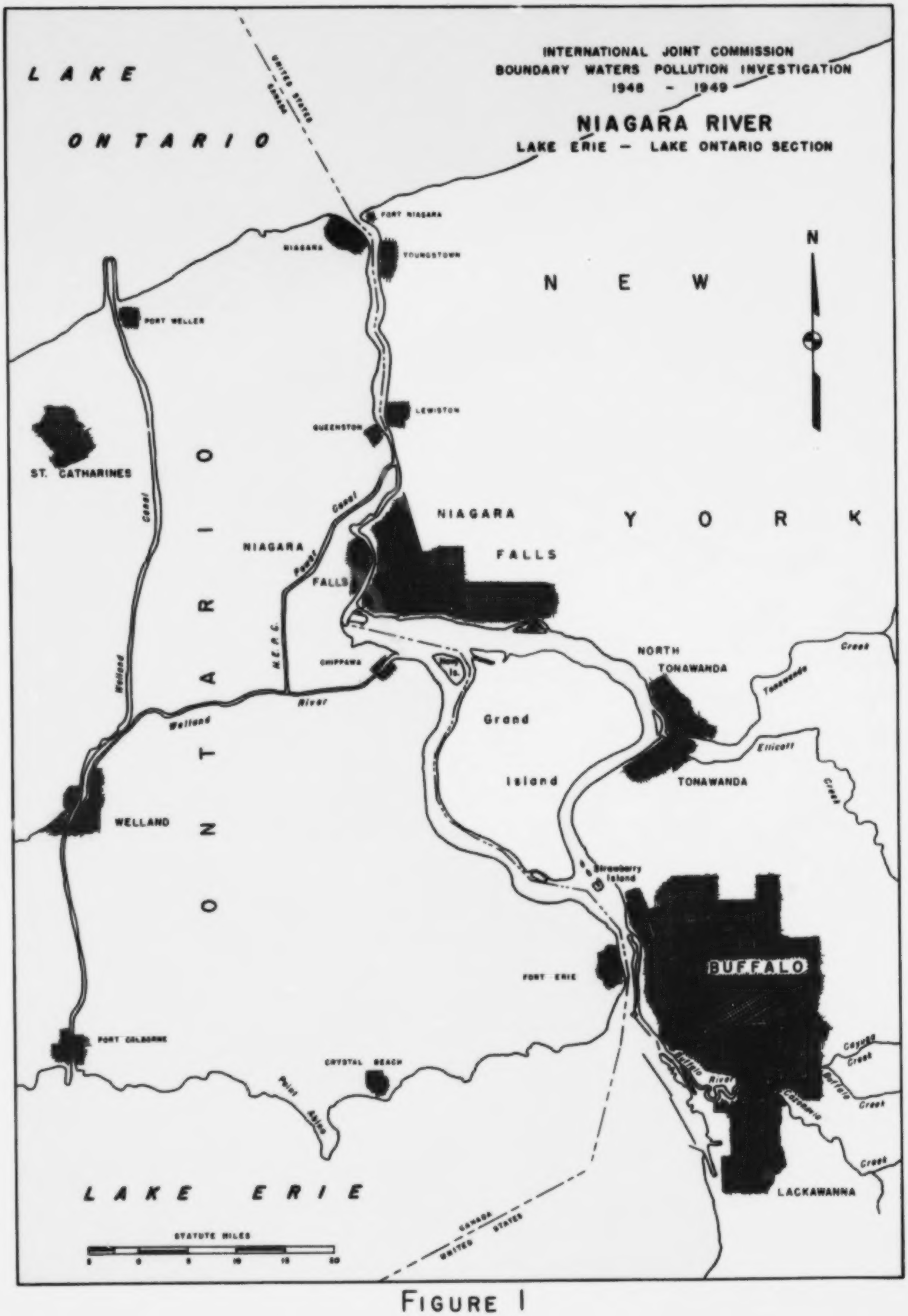

INTERNATIONAL JOINT COMMISSION
BOUNDARY WATERS POLLUTION INVESTIGATION
1948 - 1949
NIAGARA RIVER
LAKE ERIE - LAKE ONTARIO SECTION
LAKE
ONTARIO
UNITED STATES
CANADA
FORT NIAGARA
NIAGARA
YOUNGSTOWN
PORT WELLER
N
NEW
YORK
LEWISTON
QUEENSTON
ST. CATHARINES
Welland Canal
ONTARIO
NIAGARA
FALLS
NIAGARA
FALLS
Power Canal
H.E.P.C.
CHIPPAWA
Welland River
Navy Is.
Grand
Island
NORTH
TONAWANDA
Tonawanda Creek
Ellicott Creek
TONAWANDA
Strawberry Island
FORT ERIE
BUFFALO
PORT COLBORNE
CRYSTAL BEACH
Point Abino
Buffalo River
Cayuga Creek
Buffalo Creek
Cazenovia Creek
LACKAWANNA
LAKE ERIE
CANADA
UNITED STATES
STATUTE MILES
5 0 5 10 15 20

FIGURE I

with a continuing east wind, the level drops below the Low Water Datum (L.W.D.) of 570.5 feet, making it impossible, at times, for ships to pass into the harbor. On one occasion the rock bottom at Fort Erie was exposed. Similarly, a continuing southwest wind has raised the level in the harbor as much as 11 feet above L.W.D. The lake freezes late and thaws early, but shipping is normally confined to 7 months of the year.

A dumping area for dredged materials has been designated on the United States side. This area is 0.7 mile wide and extends from shore 1.4 miles into the lake in the vicinity of the mouth of Smokes Creek. The southerly limit approximately parallels the water intake line of the Western New York Water Company, the intake crib being 750 feet distant.

## THE NIAGARA RIVER

The Niagara River flows in a northerly direction from the eastern end of Lake Erie to Lake Ontario. It has a total catchment area of 265,095 square miles above Niagara Falls. The river itself drains an area of 1,688 square miles, of which 1,225 are in the United States and 463 in Canada. The stream is about 37 miles long, and divided by Niagara Falls about midway in its length into upper and lower parts.

The Niagara River leaves Lake Erie through a funnel-shaped entrance which narrows in a distance of about 1-1/2 miles to a constricted channel in rock with a minimum width of 1,500 feet and an average depth of about 17 feet where current velocities as great as 10 miles per hour occur. Navigation past these rapids is made possible by the Black Rock Canal which parallels the river for 3-1/2 miles on the United States side. Water levels in this canal are controlled by locks at the northern end of Squaw Island.

The upper Niagara River contains a number of small islands and is divided into two main channels by Strawberry Island and Grand Island.

The International Boundary follows the West or Chippawa Channel. This channel, used only by small craft, varies in width from 2,000 to 4,000 feet, and has depths from 15 to 30 feet. The West Channel divides at Navy Island and then combines with the eastern branch to form the large body of water upstream from the rapids above the Horseshoe and American Falls.

The East or Tonawanda Channel commences at Strawberry Island, immediately upstream from the southern tip of Grand Island. A dredged channel 21 feet deep lies east of Strawberry Island from the Black Rock Canal to a point opposite Motor Island. From Motor Island to Tonawanda Island there is a natural average depth of 20 to 28 feet. The balance of the East Channel is comparatively shallow, with widths in this branch varying from 1,600 to 4,000 feet. A channel 12 feet deep for vessel navigation is maintained through the lower 8-1/2 miles of the east branch to Niagara Falls , New York. Dredged material is dumped in an area approximately 900 feet square in the East Channel of the Niagara River between the northerly shore of Buckhorn Island and the channel in the east branch.

Goat Island, a small island at the brink of the Falls, divides it into two separate cataracts, namely the American and the Horseshoe Falls. In 1944 a submerged weir was constructed at right angles to the Canadian shore, upstream from the end of Goat Island, to divert a larger flow of water over the American Falls.

The lower river flows through 6.8 miles of deep gorge from the Falls to the edge of the Niagara Escarpment at Queenston and Lewiston. At the base of the falls, the water flows quietly in a deep channel before entering the narrow shallow channel of the Whirlpool Rapids. The fall in these rapids is about 50 feet in a little more than a mile, with estimated velocities up to 30 miles per hour. The Whirlpool is a circular basin in which the river direction turns nearly 90°. Under normal stages, the incoming water enters the Whirlpool on the top, encircles the basin many times and leaves beneath the inflowing water. Downstream from the Whirlpool the Lower Rapids have a fall of about 40 feet in 2 miles. For the remaining 7 miles from Lewiston to Lake Ontario, the stream widens to an average of 2,000 feet, with an average depth of about 40 feet. This quiescent part of the river is used by some lake vessels.

From a water level of 570.5 feet (L.W.D.) in Lake Erie, the upper river descends to an elevation of 562 feet at the beginning of the rapids just prior to the Falls. A further drop of 54 feet takes place in the rapids approaching the American and Horseshoe Falls, which in turn have a mean drop of about 164 feet. The lower river, at elevation 344 feet at the base of the Falls, drops through the gorge and rapids to approximately Lake Ontario level of 244 feet opposite Lewiston and Queenston. The total drop from Lake Erie to Lake Ontario is about 326 feet.

## NIAGARA RIVER TRIBUTARIES

The principal tributaries flowing into the Niagara River are the Buffalo River, Ellicott Creek and the Tonawanda (Barge Canal) Creek on the United States side, and the Ontario Hydro Electric Power Commission's power canal, carrying the Welland River and discharging at Queenston, Ontario on the Canadian side.

The Buffalo River, with its tributary streams of Cazenovia, Buffalo, and Cayuga Creeks, has a watershed of about 424 square miles or 35 percent of the area draining into the Niagara River from the United States side. From its source about 3 miles north of the Village of Arcade in Wyoming County, it flows in a meandering northwest direction to its mouth in the Buffalo Outer Harbor.

The largest drainage area on the United States side is that of Tonawanda Creek, with a watershed of 530 square miles or 43% of the total on the United States side. Its headwaters also start a few miles north of the Village of Arcade, and the stream flows north through Batavia and then in a westerly direction to its mouth on the Niagara River at Tonawanda. The Erie Barge Canal was built in 1825 across upper New York State as an inland waterway to the Hudson River and thence to the Atlantic Ocean. The canal connected into Tonawanda Creek at the hamlet of Pendleton, and that portion of the creek from Pendleton to the river became part of the Erie Canal. With this change, the flow of this portion of Tonawanda Creek was reversed under normal stream flows easterly through the Erie Canal. During periods of heavy run-off, however, the flow may be into the Niagara River. In 1918, the canal was deepened and widened and the name changed to the New York State Barge Canal or simply Barge Canal.

Ellicott Creek, with a watershed of 119 square miles, is actually a tributary of Tonawanda Creek although their confluence is less than a half mile from the Niagara River. Its flow may therefore be easterly through the Barge Canal, or into the Niagara River, depending on the flow of water in Tonawanda Creek.

Two other small streams discharge into the Niagara River on the United States side. Scajaquada Creek, with a drainage area of 22 square miles, discharges into the river at Buffalo, and Cayuga Creek, with an area of 34 square miles, discharges at Niagara Falls.

There are no Canadian tributaries of consequence above the Falls. The Welland River and power canal, with a watershed of 375 square miles, represent over 80% of the Canadian tributary area and drain into the Niagara River below the Falls. From its source about 5 miles southwest of

Hamilton, the stream meanders through four counties for a distance of 70 miles, although the east-west length of the basin is approximately 46 miles. It drops about 240 feet from the source to its former mouth above Niagara Falls at Chippawa. When the power canal was constructed the flow in nearly 4 miles of the Welland River was reversed, so that water from the upper Niagara River and the Welland River proper is discharged to the lower river at a point 7.7 miles below Chippawa.

Black Creek, another small tributary on the Canadian side with a drainage area of 37 square miles, discharges to the upper river.

A tabulation of the principal watersheds tributary to the Niagara River is given in table 3.

Table 3 PRINCIPAL DRAINAGE AREAS TRIBUTARY TO NIAGARA RIVER

| Stream | Drainage Areas in Square Miles | | |
|---|---|---|---|
| | United States | Canada | Total |
| Buffalo River | 424 | -- | 424 |
| Scajaquada Creek | 22 | -- | 22 |
| Tonawanda Creek (Barge Canal) | 530 | -- | 530 |
| Ellicott Creek | 119 | -- | 119 |
| Black Creek | -- | 37 | 37 |
| Cayuga Creek | 34 | -- | 34 |
| Welland River | -- | 375 | 375 |
| Miscellaneous Upper River areas | 77 | 33 | 110 |
| Miscellaneous Lower River areas | 19 | 18 | 37 |
| TOTAL | 1,225 | 463 | 1,688 |

## LAKE ONTARIO - NIAGARA RIVER OUTLET

That portion of Lake Ontario, included in the Lake Erie-Lake Ontario Section, comprises an area within a radius of about 12 miles from the outlet of the Niagara River. Several small creeks, including Four Mile and Six Mile Creeks with a drainage area of 33 square miles, discharge directly to Lake Ontario on the United States side. In Canada, Two Mile, Four Mile, and Eight Mile Creeks, with drainage area of 44 square miles, flow into Lake Ontario.

Lake Ontario is a very deep lake with depths ranging from 500 feet to a maximum of 778 feet. In the area under study the depths reach 300 feet. At the outlet of the Niagara River, the Niagara Bar and the Rumsey Shoal extend a distance of 3 miles into the lake, with water depths ranging from 9 to 20 feet. There has been no dredging for navigation purposes in the lower Niagara River or in Lake Ontario at the outlet of the river since 1911. Fine sand from the Niagara Bar is dredged for commercial sale.

The surface of the lake is 248 feet above sea level, making two-thirds of the depth below sea level. A surface current usually moves easterly at a rate of about 8 miles per day, with the strongest current along the southern shore. Unlike Lake Erie, heavy waves are slow to rise and to subside. Lake Ontario freezes only near shore, but its harbors are closed about 5 months in the year.

## TOPOGRAPHY

The Lake Erie-Lake Ontario Section is included in the region comprising central and western New York, western Ontario, and northern Pennsylvania. Viewed broadly, the region consists of a series of terraces or plains descending northward to Lake Ontario and separated by three northward facing escarpments. These escarpments owe their origin and preservation to the fact that they are composed of soft, easily eroded shales below, capped by hard and more resistant limestones and dolomites.

The Portage Escarpment south of the Lake Erie-Lake Ontario Section forms the southern boundary of the Erie plain. This includes the southern part of the triangular Ontario peninsula between Lake Erie and Lake Huron, and a narrow strip along the south shore of Lake Erie. This escarpment extends from Ohio, where it is low and broken by broad valleys, and continues across northwestern Pennsylvania into southwestern New York, where it is abrupt and nearly straight. From Cattaraugus Creek in New York State and extending east, the Portage Escarpment is less abrupt and is broken by deep narrow valleys. East of Auburn, New York, it merges into the Onondaga Escarpment.

The Onondaga Escarpment bounds the Erie plain on the north and separates it from the Huron plain. This escarpment crosses the Lake Erie-Lake Ontario Section in an east-west direction. It is less evident at Buffalo but becomes more prominent east of the city. Across Ontario it is obscured by glacial drift. The Huron plain includes a strip of western New York, the northern part of the triangular peninsula of Ontario and a part of the bed of Lake Huron. Its surface is nearly level and lies about 600 feet above sea level.

Similarly, the Niagara Escarpment crosses the Lake Erie-Lake Ontario Section, separating the Huron and Ontario plains. The Ontario plain includes the shallow basin of Georgian Bay, part of the Province of Ontario between this Bay and Lake Ontario, part of the bed of the Lake, and a strip on the south and west sides of Lake Ontario in New York State. The surface of this plain is irregular, although nearly level in some areas. The Niagara Escarpment can be traced from western New York to northern Illinois. At Rochester, New York, it is about 100 feet high and at Lewiston about 200 feet. At Hamilton, Ontario, it turns northwest and extends to Georgian Bay where it reaches a height of 800 feet. It continues across the northern end of Lake Michigan, reappears in the Green Bay peninsula in Wisconsin, and crosses southwest into Illinois, where it dies out.

The drainage areas of the Niagara River have been established by these escarpments. Three distinct drainage basins in Ontario run parallel for many miles, although the terrain is gently rolling and without high ridges. In New York State there are two main drainage area, Tonawanda Creek and Buffalo River.

## GEOLOGY

During the Pleistocene Epoch four glacial ice invasions entered the Mississippi basin. These glaciers carried quantities of boulders, sand and clay. When the ice melted, the surface everywhere was covered with accumulations of glacial drift. In the Lake Erie-Lake Ontario Section, the drift is comparatively thin, from 2 to 150 feet, and the surface appears quite flat, reflecting in a measure the structure of the underlying rock.

Distinct geological formations occur in belts running almost east and west and divided by the three escarpments. The bed rock of the Erie, Huron, and Ontario plains, except for a few small igneous dikes, are wholly sedimentary, laid down during the late Ordovician, Silurian, and Devonian periods of the Paleozoic Era. These consist principally of shales, limestones, sandstones, dolomites, and gypsum. In western New York and north of Lake Ontario the beds have a general east-west trend and a south dip.

The Portage Escarpment is formed by sandstones and sandy shales of the late Devonian Age, having a total thickness of 3,000 feet or more. The Huron plain is occupied by late Silurian shales and sandstones. The Onondaga Escarpment is formed from Onondaga limestone of the middle Devonian Age. Middle Devonian shales and limestones occupy the Erie plain.

The Niagara Escarpment is capped by limestone of the Niagara group, middle Silurian Age. It is this escarpment that the waters of the Niagara River have cut back to form the gorge below Niagara Falls as it is today. The greater part of the Ontario plain is occupied by lower Ordovician strata, chiefly limestone. The remainder, comprising the bed of the southern portion of Lake Ontario and extending along the south side of the lake and thence to Georgian Bay, is late Ordovician limestone and early Silurian sandstone and shale.

## CLIMATE

The climate of the Lake Erie-Lake Ontario Section is subjected to many variations caused by storms in the Great Lakes area, but extremes of temperature are moderated by the large water surfaces to the north and south. Buffalo, in particular, is subject to the storms that sweep in from Lake Erie. Sub-zero temperatures occur occasionally during the winter months, but the average and extreme low temperatures inland are similar to those recorded on the shore of either lake. The area is free from tornadoes, earthquakes, and floods.

The east end of Lake Erie, some quiet portions of the Niagara River, and Lake Ontario along its shore, freeze over during the colder months. Ice jams occur in the Niagara River, particularly in the vicinity of Strawberry Island and the south end of Grand Island. These jams affect the flow in the river. Almost yearly, ice floes from Lake Erie and the Niagara River accumulate in the pool below the Falls. Mist arising from the Falls freezes the ice cakes together, forming a so-called "ice bridge." In 1909, an unusual amount of ice accumulated to form a bridge, which reached a height about 40 feet above normal water level. Also noteworthy was the jam of 1938 which damaged power plants located in the gorge and which destroyed the Falls View Arch Bridge by raising it off its abutments located 20 feet above the normal water level. During the winter of 1935-36, the low water level in the Great Lakes combined with sub-freezing temperatures to form an ice barrier between the south end of Goat Island and the United States bank of the Niagara River, completely drying the American Falls.

Records of weather stations in the area show considerable variations in precipitation. Heavy rains occur frequently. The maximum recorded intensity has been 4.3 inches per 24 hours. Snowstorms are frequent during the winter months. The Buffalo area has had annual cumulative snow falls as great as 10 feet. Inland, the snowfall is less, and the ground may be bare for part of the winter. Prevailing winds are from the west and southwest with average velocities between 10 - 15 miles per hour. Infrequently wind storms from the north or east are noted. The highest recorded velocity in the area is 91 miles per hour.

Climatological data on temperature, precipitation, and wind for selected stations are given in table 4.

## Table 4 - CLIMATOLOGICAL DATA FOR SELECTED STATIONS

(From Period of Record to 1947, Inclusive)

| STATION | Temperature - Degrees F. | | | | Precipitation - Inches | | | | Wind | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Years of Record | Annual Average | Maxi-mum | Mini-mum | Years of Record | Annual Average | Maxi-mum Annual | Mini-mum Annual | Years of Record | Average Velocity MPH | Pre-vailing Direction |
| **UNITED STATES** | | | | | | | | | | | |
| Derby. New York | 3 | 48.1 | 98 | - 4 | 3 | 39.31 | 43.33 | 30.44 | 3 | - | SW |
| Buffalo, New York | 75 | 46.8 | 99 | - 20 | 78 | 36.00 | 60.24 | 22.16 | 78 | 14.5 | SW |
| Lockport, New York | 48 | 47.1 | 103 | - 24 | 62 | 31.08 | 46.48 | 17.57 | 55 | - | SW |
| Lewiston, New York | 13 | 48.6 | 107 | - 11 | 26 | 25.67 | 39.53 | 17.64 | 13 | - | SW |
| Wilson, New York | 0 | - | - | - | 6 | 33.14 | 40.80 | 25.74 | 6 | - | SW |
| **CANADIAN** | | | | | | | | | | | |
| Port Dover, Ontario | 33 | 46 | 104 | - 28 | 33 | 35.21 | - | - | - | - | - |
| Welland, Ontario | 45 | 47 | 100 | - 24 | 45 | 33.88 | - | - | - | - | - |
| Vineland, Ontario | 12 | 48 | 103 | - 14 | 12 | 20.00 | - | - | 13 | 9.5 | W |
| St. Catharines, Ontario | 21 | 48 | 104 | - 12 | 21 | 27.03 | - | - | - | - | - |
| Toronto, Ontario | 105 | 45 | 105 | - 26 | 105 | 32.18 | - | - | 23 | 11.4 | SW |

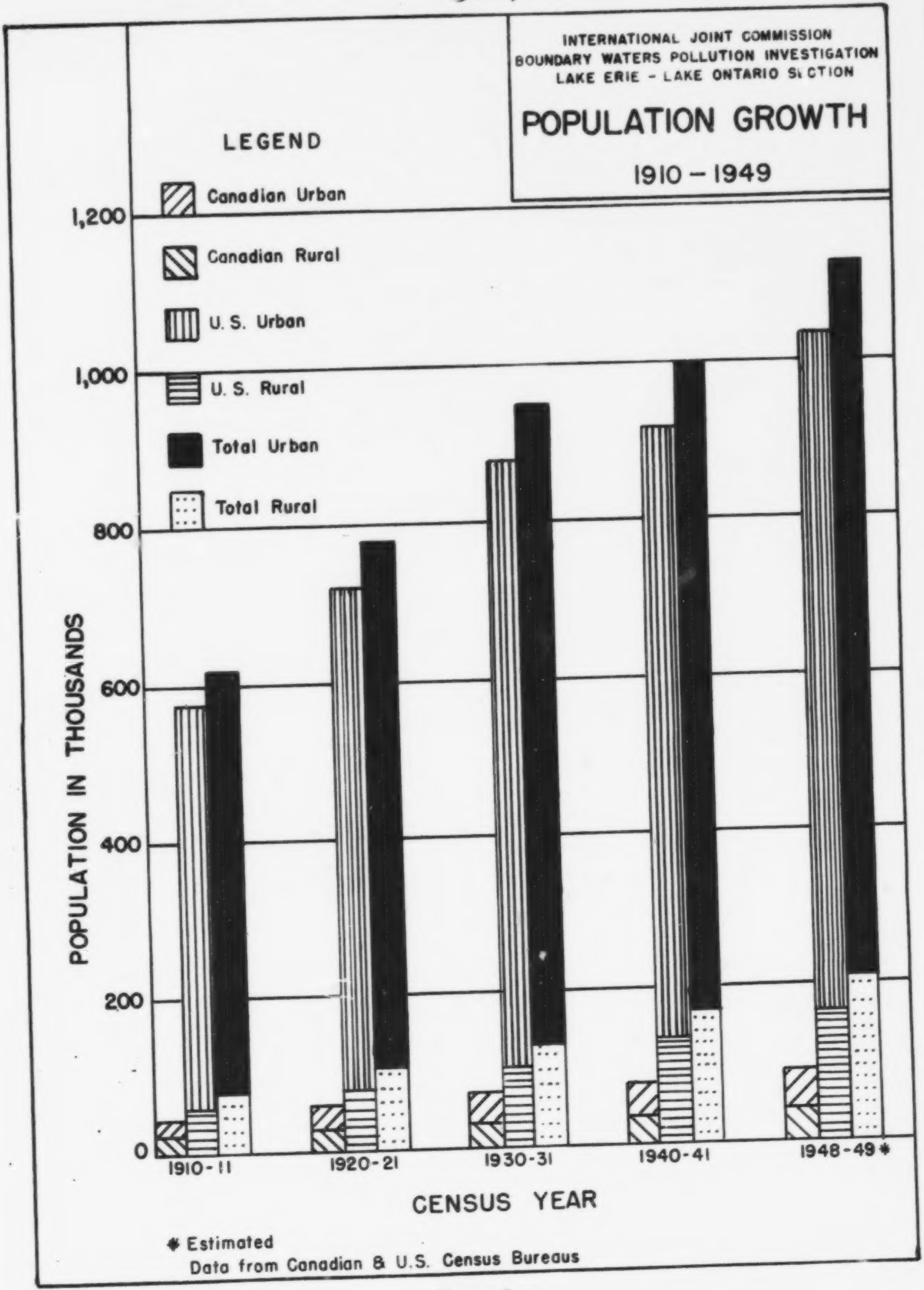
POPULATION

The population in the Lake Erie-Lake Ontario Section approximated 997,000 persons, based on estimates from the data in the 1940-41 census. Recent estimates (1949) indicate an increase of population to about 1,125,000 persons, most of which has occurred in the urban areas. The 1949 population is described as 19% rural and 81% urban. Municipalities having a population under 1,000 were classified as rural. Figure 2 shows the growth of population from 1910 to 1949.

About 70% of this population lives on the United States side of the upper Niagara River in the intensely developed zone from Buffalo to Niagara Falls. In contrast, the Canadian side is largely parkway and rural area. The distribution of population by drainage basins for the entire area is shown in table 5, and the population increase for principal municipalities is shown in table 6. The number of persons per square mile in this area based on 1949 estimates, was about 850 for New York, 200 for Ontario, and 670 for the entire Section.

The Tonawanda-Ellicott Creek drainage basin, included in the Lake Erie-Lake Ontario Section is tributary to the New York State Barge Canal. The Barge Canal drains easterly from the Niagara River for about 11 months each year, except during periods of excessive run-off. At such times the creeks discharge into the Niagara River. This drainage basin represents an area of about 650 square miles or 40% of the entire Section, and a population (1949 estimate) of about 100,000 persons, or nearly 10% of the entire Section.

30-A



* Estimated
Data from Canadian & U.S. Census Bureaus

Figure 2

Table 5 - DISTRIBUTION OF POPULATION BY DRAINAGE BASINS, 1940-41 AND 1949

| Drainage Basin | New York | | | Ontario | | | Combined | | |
|---|---|---|---|---|---|---|---|---|---|
| | Rural | Urban | Total | Rural | Urban | Total | Rural | Urban | Total |
| 1940-41<br>Lake Erie | 13,100 | 27,680 | 40,780 | 1,250 | 620 | 1,870 | 14,350 | 28,300 | 42,650 |
| Upper Niagara River | 116,280 | 675,710 | 791,990 | 4,670 | 6,600 | 11,270 | 120,950 | 682,310 | 803,260 |
| Lower Niagara River | 2,260 | 79,310 | 81,570 | 24,350 | 34,470 | 58,820 | 26,610 | 113,780 | 140,390 |
| Lake Ontario | 3,320 | - | 3,320 | 5,570 | 1,540 | 7,110 | 8,890 | 1,540 | 10,430 |
| Totals | 134,960 | 782,700 | 917,660 | 35,840 | 43,230 | 79,070 | 170,800 | 825,930 | 996,730 |
| 1949 (Estimate)<br>Lake Erie | 16,300 | 32,700 | 49,000 | 1,200 | 1,300 | 2,500 | 17,500 | 34,000 | 51,500 |
| Upper Niagara River | 144,700 | 738,500 | 883,200 | 4,700 | 7,500 | 12,200 | 149,400 | 746,000 | 895,400 |
| Lower Niagara River | 2,600 | 93,500 | 96,100 | 29,800 | 39,600 | 69,400 | 32,400 | 133,100 | 165,500 |
| Lake Ontario | 3,900 | - | 3,900 | 6,700 | 1,700 | 8,400 | 10,600 | 1,700 | 12,300 |
| Totals | 167,500 | 864,700 | 1,032,200 | 42,400 | 50,100 | 92,500 | 209,900 | 914,800 | 1,124,700 |

Table 6 - POPULATION CHANGES IN PRINCIPAL MUNICIPALITIES

| Municipality | 1910-11 | 1920-21 | 1930-31 | 1940-41 | 1949 (Estimated) |
|---|---|---|---|---|---|
| Lake Erie - Lake Ontario Basin | 615,700 | 779,600 | 946,800 | 996,700 | 1,124,700 |
| United States Side | | | | | |
| Lackawanna, New York | 14,549 | 17,918 | 23,948 | 24,058 | 30,000 |
| Buffalo, New York | 423,715 | 506,775 | 573,076 | 575,901 | 617,900 |
| Kenmore, New York | 1,020 | 3,160 | 16,482 | 18,612 | 21,000 |
| Tonawanda, New York | 8,290 | 10,068 | 12,681 | 13,008 | 15,000 |
| North Tonawanda, New York | 11,995 | 15,482 | 19,019 | 20,254 | 27,000 |
| Niagara Falls, New York | 30,445 | 50,760 | 75,460 | 78,029 | 92,000 |
| Batavia, New York | 11,613 | 13,541 | 17,375 | 17,267 | 20,000 |
| Canadian Side | | | | | |
| Fort Erie, Ontario | 1,146 | 1,546 | 2,383 | 6,595 | 7,500 |
| Niagara Falls, Ontario | 9,248 | 14,764 | 19,046 | 20,589 | 21,700 |
| Welland, Ontario | 5,318 | 8,654 | 10,709 | 12,500 | 16,000 |

## LAND USE AND DEVELOPMENT

The Lake Erie-Lake Ontario watershed is used almost entirely for agricultural and industrial purposes. The area adjacent to the Niagara River, especially on the United States side, is utilized for industrial development, while the rest of the Section is devoted to agriculture. Sport fishing in certain areas is enjoyed, but commercial fishing is not extensive. Bathing beaches are located along the lakes, and on Grand Island in the upper Niagara River.

Agriculture in the Ontario area is devoted chiefly to fruit farms, vineyards, and market gardens. In New York the watershed is located predominantly on the Huron plain, with its poorly drained soil, and is used mostly for hay, grain, and pasture. While dairying assumes a prominent place, poultry also is an important source of farm income.

Because of the availability of cheap hydro-electric power on the Niagara River, many industries were attracted early to this region. Industrial development on both sides of the river is marked with such processes as electro-chemical, ferro alloy, abrasive, chlorine and caustic soda, carbide, steel, fertilizer, and pulp and paper. There is also a large production of acids, coke and by-products, dyes and intermediates, cellulose and rayon, organic chemicals, and petroleum products. There has been a rapid growth of these industries in the last 40 years, and particularly marked during the periods of the two World Wars.

# CHAPTER IV

# HYDROMETRIC DATA

> "Observe always that everything is the result of a change, and get used to thinking that there is nothing Nature loves so well as to change existing forms and to make new ones like them."
>
> \- Meditations IV

Hydrometric data on a watercourse are used to evaluate the effects of flow, currents, distribution into channels, and other related factors which may influence stream pollution. The large volumes of lake water in the Lake Erie-Lake Ontario Section, combined with the swift and variable currents of the Niagara River, serve to dilute and transport the incoming wastes. Pollutants which are concentrated at the point of discharge may become greatly diluted in certain areas or may remain concentrated in others. Even diluted wastes may be carried long distances and cause objectionable conditions in the boundary waters. Pollution is generally most significant at its immediate point of discharge. The extent of its subsequent importance will be influenced by the time, volume and route of flow, the degree of turbulence, and other stream characteristics.

A thorough knowledge of lake and river currents is essential in determining transboundary travel of polluted waters.

## SOURCES OF INFORMATION

The hydrometric data presented in this report were obtained almost entirely from available records and reports of various Governmental agencies. Flow records for the various power diversion installations were obtained from the private companies concerned.

Long term flow records for the Niagara River at Buffalo were furnished by the U. S. Lake Survey. Discharge records at the mouths of tributary streams emptying into the Niagara River were inadequate. The U. S. Geological Survey furnished short term flow records applicable to the Buffalo River and to Tonawanda Creek. No flow measurements for the Canadian tributaries involved in this study could be obtained. Consequently, flow estimates for the Canadian and other United States tributaries were computed from the Buffalo River and Tonawanda Creek records.

Certain information on the course of pollution in both Lake Erie and the Niagara River, particularly in regard to transboundary movement, was obtained from float studies made by the United States field staff.

## FLOW CHARACTERISTICS

Information on the flow characteristics and the influencing factors are presented for both the Niagara River and its tributaries.

### Niagara River

The average flow of the Niagara River at its inlet from Lake Erie for the 90-year period (1860-1949) was 202,000 cubic feet per second (c.f.s.). Flow velocities increase gradually within the funnel shaped inlet, and approach a maximum velocity of about 15 feet per second (f.p.s.) within the constricted channel in the vicinity of the Peace Bridge.

To facilitate navigation around these rapid currents the Black Rock Canal was constructed adjacent to the river. This canal was completed in 1913, and replaced that part of the Erie Barge Canal connecting Buffalo and Tonawanda. The Black Rock Canal extends northward from the inner harbor of Buffalo to the downstream end of Squaw Island, a distance of 3.5 miles. Flow in the canal is regulated at the Black Rock Locks located at the northern terminus. Data obtained from the Corps of Engineers for 1948 operation show an average flow of about 200 c.f.s. through the canal, indicating that low velocities prevail.

About 4 miles downstream from the river inlet, the channel widens and flow velocities of from 2 to 5 f.p.s. occur. The river is divided at Grand Island into the East (Tonawanda) Channel and the West (Chippawa) Channel. River distances around Grand Island are 13 miles for the East Channel and 9 miles for the West Channel. The flow distribution shows that about 43% of the total follows the east branch and 57% follows the west branch. Velocities in the deeper East Channel average about 2.5 f.p.s., whereas in the West Channel averages are about 5 f.p.s.

The east and west branches combine about 4 miles upstream from Niagara Falls to form the headwaters approaching the upper rapids or cascades. The river is divided at the rapids by Goat Island which also separates the American and the Horseshoe Falls. Previous to the construction of a submerged rock-fill weir above the cascades on the Canadian side, flow over the American Falls averaged only about 4.7% of the total flow. Ice jams above Goat Island tended to close off the American Falls even further, and on one occasion in 1936 the flow was completely stopped. Since completion of the submerged weir in 1944, flow over the American Falls has been increased to about 9% of the total, or an average of about 11,000 c.f.s. Total flow over the Falls, because of water diverted for power uses, is only about 118,000 c.f.s, or 58% of the Niagara River flow at Buffalo.

The lower river below the Falls flows quietly for about two miles in a deep channel from the Maid of the Mist pool to the Whirlpool Rapids. The swiftest velocities in the river occur in these rapids, extending about one mile above the Whirlpool. Velocities as high as 45 f.p.s. (30 miles per hour) have been estimated. The full diluting power of the river is probably first realized within this stretch.

The lower river enters the Whirlpool where the circulating currents complicate the flow pattern. The detention time within the Whirlpool has not been estimated but surface drift material has been known to remain there for days. The two-mile section downstream from the Whirlpool is known as the Lower Rapids. The flow entering this narrow channel discharges to the wider quiescent reaches of the lower river at Lewiston. This final 7-mile length of the river flows sluggishly at an estimated 2 f.p.s. velocity into Lake Ontario.

### Factors Influencing Flow Conditions

The rate of flow in the Niagara River is dependent almost entirely upon the water level of Lake Erie at Buffalo. As a consequence, the river is not subject to the wide variations of discharge as are common to most streams affected by seasonal droughts and floods. Nevertheless, due to influencing factors limited periodic and sudden variations do occur. The mean monthly flow figures range from 117,000 to 253,000 c.f.s.

The most significant factors effecting the discharge rate of the river are those causing long term periodic variations. Of secondary importance are those factors which tend to cause sudden fluctuations in discharge. Ice conditions, tributary inflow, and power and navigation diversion systems cause relatively minor changes in the river discharge. These, nevertheless, effect changes in flow conditions which may in turn alter the pollution distribution within the river. These various influencing conditions are discussed separately.

Long term periodic cycles of the annual mean water levels at Buffalo have a dominating effect upon the river flow. Records indicate these cycles recur irregularly with varying durations of about 10 to 30 years, and have caused a range of mean monthly water level at Buffalo of about 5 feet.

These cycles result mainly from corresponding cycles of precipitation in the Great Lakes basin, but are also effected by numerous other meteorological factors. Records show that this variation in lake level has produced a range in the annual mean discharge rate of the river in the order of 75,000 c.f.s. Minor cyclical variations occur annually with seasonal changes, causing somewhat higher flows in the summer than in the winter.

Sudden fluctuations of water level at Buffalo occur, due primarily to winds and changes of barometric pressure. At times of high velocity the prevailing westerly winds have frequently raised the level at Buffalo by several feet. Similarly, easterly winds may lower the lake level at Buffalo. These disturbances may also produce seiches or oscillations of the lake surface which sometimes add several feet to the effect of wind and barometric pressure in changing the water level at Buffalo. Although these conditions have cuased a range in stage as great as 15 feet, their duration is usually short. Accordingly, they produce a change in river discharge for only a few hours because of the time lag in transmitting these fluctuations downstream. Generally, they do not alter materially the mean monthly discharges.

Ice conditions along the Niagara River vary from year to year, depending upon the amount and location of ice. Usually the effect on the discharge rate is negligible, but ice stoppages have caused a flow decrease of as much as 20,000 c.f.s. The more extensive of these ice jams are caused by the spring break-up of the Lake Erie ice field. On the upper river ice floes accumulate on reefs above the river inlet, in shoal areas, and in the shallow pools above the upper rapids. These jams tend to produce temporary changes in river currents. The ice bridges which form nearly every year in the Maid of the Mist pool probably have little effect on river flow. Serious ice jams have occurred at the outlet of the lower river causing backwater to extend as far upstream as the lower rapids.

The flow of tributaries into the Niagara River is relatively insignificant. Consequently, seasonal variation in run-off from them is of minor importance in the total river flow. The average inflow for the entire basin is about 1,340 c.f.s.

Water is diverted from the Niagara River for power, navigation, and domestic and industrial uses. Power diversions use large quantities of water which are subsequently returned to the river, whereas the minor quantity of water used for navigation is not returned to the river. The water diverted for domestic and industrial purposes is relatively small in volume.

Diversions from the river for power generation are limited by joint agreements between United States and Canada. The original authorization by virtue of Article 5 of the Boundary Waters Treaty (1909-1910) permitted diversions of 36,000 c.f.s. for Canada and 20,000 c.f.s. for the United States. During World War II subsequent authorizations made possible temporary additional diversions of 18,000 c.f.s. for Canada and 12,500 c.f.s. for the United States. In 1948, a further flow of 2,500 c.f.s. was authorized for Canada to be diverted through the Welland Ship Canal only in the non-navigation season. The total permissible diversion for power is therefore 89,000 c.f.s., 56,500 c.f.s. of this being allocated to Canada and 32,500 c.f.s. to the United States.

The total actual diversion for power purposes averaged about 84,200 c.f.s. or about 42% of the river flow for the 5-year period 1945-1949, with 53,000 c.f.s. being used by Canada and 31,200 c.f.s. by United States. Except for the water diverted for power through the Welland Canal, the entire power diversion is withdrawn from the upper river within 2 miles of Niagara Falls. Approximately 84% of this diversion is returned to the river within or adjacent to the Maid of the Mist pool below the Falls. The remaining 16% is used by the Queenston Plant of the Hydro Electric Power Commission of Ontario, located about 6 miles below the Falls with its discharge at that point.

A new treaty providing additional diversion for power purposes was signed February 27, 1950 and awaits ratification by both Governments to make it effective. This treaty is intended to safeguard the scenic grandeur of the Falls by maintaining an adequate flow over it and by authorizing construction of control works to ensure an unbroken crestline at the Falls. Flow over the Falls is not to be reduced to less than 100,000 c.f.s. during daylight hours approximately, and 50,000 c.f.s. during darkness, unless additional water is required for flushing of ice in the river. This in effect would reduce the total flow of water over the Falls to an average of about 35% of the flow of the Niagara River at Buffalo. The estimated average flow of water available for power diversion under the new treaty is 131,000 c.f.s., which is to be divided equally between the two countries. Any change in the hydraulic regimen of the river may produce effects which cannot be predicated from present limited information.

Diversion from the river for navigation purposes includes the water used to augment flow in the New York State Barge Canal and that used in the Welland Ship Canal. Although the latter connects Lake Erie to Lake Ontario directly, in effect it reduces the river flow by an amount equal to the canal flow.

For the operation of the Barge Canal, a flow of approximately 1,000 c.f.s. is required during the navigation season which extends usually from April 1 to December 1. The principal source of this water is the Niagara River.

Practically the entire flow during dry weather is from the river, and only for one or two days each year is the flow from Tonawanda Creek adequate for canal requirements. During most of the four months when the canal is closed to navigation, somewhat less water passes through, while no water is diverted during a 1-month period when the canal is dewatered for inspection and repairs.

Operating data for the Welland Canal during 1947 and 1948 show an average maximum monthly flow of about 6,000 c.f.s. Probably an average reduction in Niagara River flow of about 2% is produced by this diversion.

Niagara River Tributaries

Basic flow data for Niagara River tributaries are incomplete, as indicated in table 7. Therefore, flows for the major tributaries were estimated. Except for the Tonawanda Creek discharge, the flows for all tributaries were based on data for the Buffalo River tributaries where most complete records were available. These results are shown in table 8.

Table 7 - NIAGARA RIVER AND TRIBUTARY GAGING STATIONS

| Stream | Location of Gaging Station | Period of Record | Discharge c.f.s. | | |
|---|---|---|---|---|---|
| | | | Average | Maximum | Minimum |
| Niagara River | Buffalo, N. Y. | 1860-1949 | 202,000 | 253,000* | 117,000* |
| Buffalo River Tributaries | | | | | |
| Buffalo Creek | Gardenville, N.Y. | 1939-1949 | 191 | 14,000 | 0.7 |
| Cayuga Creek | Lancaster, N. Y. | 1939-1949 | 126 | 7,480 | 0.5 |
| Cazenovia Creek | Ebenezer, N. Y. | 1941-1949 | 213 | 11,200 | 3.7 |
| Tonawanda Creek | Batavia, N. Y. | 1944-1948 | 220 | 4,600 | 1.5 |

* Represents maximum and minimum of monthly mean discharge.

Table 8 - ESTIMATED TRIBUTARY DISCHARGES AT CONFLUENCE WITH NIAGARA RIVER

| Tributary | Discharge Point | River miles from Niagara River Mouth | Average Discharge c.f.s. -Estimated |
|---|---|---|---|
| United States | | | |
| Cayuga Creek (Niagara Falls) | Niagara River, East Channel | 21.0 | 49 |
| Tonawanda Creek | Niagara River, East Channel | 26.4 | - 151 * |
| Scajaquada Creek | Upper Niagara River | 34.4 | 32 |
| Buffalo River | Buffalo Harbor | 37.8 | 600 |
| Miscellaneous | | | 139 |
| Canada | | | |
| Welland River - HEPC Canal | Lower Niagara River | 9.0 | 543 |
| Black Creek | Upper Niagara River | 24.3 | 54 |
| Miscellaneous | | | 74 |
| TOTAL | | | 1,340 |

* Negative discharge represents the difference between Barge Canal requirements (1,000 c.f.s.) and average Tonawanda Creek flow (849 c.f.s.)

The average run-off for the Niagara River drainage basin is about 1.40 c.f.s. per square mile, with 1.37 c.f.s. per square mile on the United States side and 1.45 c.f.s. per square mile on the Canadian side.

It should be noted that flows in the lower reaches of both Tonawanda Creek and the Welland River have been reversed in direction from their natural courses. Tonawanda Creek has been reversed for a distance of about 12 miles from the river, this section serving as the western end of the Barge Canal. The total of 1,000 c.f.s. required for the operation of the Barge Canal is contributed in part from Tonawanda Creek above the hamlet of

Pendleton, and Ellicott Creek at Tonawanda, with the remainder being diverted from the Niagara River. Therefore, any flow originating from storm water run-off in the basin above Pendleton in excess of the 1,000 c.f.s. would discharge into the Niagara River. Since during the non-navigation season less water is used in the canal, such flows are more likely to discharge into the Niagara River. The entire flow from both Tonawanda and Ellicott Creeks discharges into the Niagara River for about 1 month each year when sections of the canal are dewatered.

The Welland River has been reversed for a distance of about 4 miles where the Hydro Electric Power Commission's power canal diverts the flow to the Queenston Plant on the lower river. Flow in the power canal is about 14,000 c.f.s. Comparison of this flow with the average Welland River basin inflow of about 540 c.f.s. indicates that the Welland River would not discharge into the upper Niagara River.

The Buffalo River is a navigable channel extending a distance of nearly 6 miles from Buffalo Harbor to the confluence of the Buffalo and Cazenovia Creeks. A depth of about 21 feet is maintained in the river in order to facilitate traffic of lake vessels to the industries. The channel is presently being dredged to depths of 22 and 23 feet in certain sections. The Buffalo River offers an unusual pollution control problem because of the many large industries located along its banks.

The average flow in the Buffalo River for the period of record (1940-1949) is about 600 c.f.s. However, flow during the months of July, August, and September, for the same period of record, averaged about 89 c.f.s. or 58 million U. S. gallons per day (M.G.D. - U.S.). The lowest recorded flow for these months occurred in 1949, when the average river flow was about

57 c.f.s. or 37 M.G.D. (U.S.). These discharge figures include about 10 M.G.D. (U.S.) of water, supplied to industries from the City of Buffalo's municipal water system, which is subsequently discharged into the river. Present industrial demands along the river require about 125 M.G.D. (U.S.). Except for the 10 M.G.D. (U.S.) supplied by the city, this entire industrial consumption is recirculated from the Buffalo River. Thus, during the summer period, the river water is re-used by the various industries an average of from two to three times. During these dry periods, therefore, the pollutants in the river become increasingly concentrated. Not only does the river become grossly polluted, but the water is made undesirable for subsequent industrial use. A plan, known as the Lake Erie Cooling Water Project, has been proposed as a means of partially alleviating these conditions. This project provides for pumping from 120 to 180 M.G.D. (U.S.) of water from Lake Erie for industrial use. This water would then be discharged to the Buffalo River, thereby creating a more continuous flow toward the Niagara River.

Variations in the discharge of the Buffalo River present additional pollution hazards. A rising of the lake surface at Buffalo as is commonly caused by prevailing southwesterly winds may prevent any discharge from the river or may even reverse the flow over a considerable distance. Of even greater significance are the sudden high flows from the river caused by either heavy storms on the watershed or by easterly winds lowering the lake surface. In those instances, slugs of pollution from the Buffalo River have been responsible for fish kills, and have had an adverse effect on water supplies downstream on the Niagara River.

Several plans to provide an additional entrance to the Buffalo River from the outer harbor are presently being considered. New pollution problems will be created if any such change is made in the location of the river's discharge into the harbor.

## TRANSBOUNDARY CURRENTS

The inter-mixing of waters in the upper Niagara River across the International Boundary is hindered by the high velocity of flow. This results in a striking horizontal stratification of the flowing water. This phenomenon is made visible by differences in the turbidity and color of the water, and has been substantiated by the results of the chemical and bacteriological data.

A study of surface currents in the eastern end of Lake Erie and in the Niagara River was conducted by the United States field staff during the fall of 1949, through the release of some 540 small wooden surface floats at six points located about one-half mile from the Canadian and from the United States shores of Lake Erie. Nearly 400 observations on these floats were reported by residents of both United States and Canada. No method was available, however, for following the course of the various floats from their points of release to the points where they were observed.

Many of the floats placed in Canadian waters were found to remain in coves along the Canadian shore for several weeks, or presumably until the wind direction changed. A few crossed the International Boundary to the United States shore near Wanakah, New York. Some floats placed in United States waters crossed to the Canadian shore, others to the Buffalo Harbor area, and a still greater proportion entered the Niagara River.

The influence of the main flow toward the river was observed particularly with floats placed about 4 miles from the river inlet along the Canadian shore.

A study of the currents within the upper Niagara River was attempted, utilizing repeated observations on floats which reached the river inlet. However, due to the lack of continuous observations on single floats, no significant analysis of the flow patterns could be made. For the same reason, although a major portion of the floats observed in the upper river were reported at locations across the boundary from their original release point, it could not be determined whether these floats crossed the boundary within Lake Erie or within the river. In any case, the floats responded to surface currents or to wind action; therefore, these studies are inconclusive as to deeper currents affecting the main body of water. In general, the distribution of reported floats in the east and west branches of the river agrees with stream flow data that over half of the total flow in the upper river enters the West Channel.

The observations made on floats in the lower river were too limited to be conclusive. It is known that cross-channel mixing together with high turbulence causes a marked transboundary flow of water throughout both the lower rapids and the Whirlpool.

STRAWBERRY ISLAND

Early in 1947 concern was expressed by the New York State Department of Health over the dredging of Strawberry Island, located in the upper Niagara River upstream from the head of Grand Island. The matter was called to the attention of the U. S. Department of State, which in turn referred the question to the International Joint Commission. It was feared that continued dredging of the island would weaken it to the point where it might be removed by natural forces and would change the hydraulic regimen of the Niagara River. This might permit pollution, now following the United States shoreline, to enter the relatively uncontaminated West Channel where it is proposed to locate several water supply intakes.

In the past there has been intermittent dredging in the bed of the Niagara River in the vicinity of Strawberry Island. However, the State of New York passed a statute effective May 23, 1942 prohibiting further dredging in the bed of the upper river. Present dredging of Strawberry Island is being done by a private company under a permit issued by the U. S. Department of Army. It authorizes excavation of material in the interior of the island, specifies the width of berms that must be left around the island, and provides that the company must prevent erosion of the shoreline or the occurrence of any condition that may disturb the hydraulic regimen of the river.

A special subcommittee was appointed by the International Joint Commission to study the question. The subcommittee submitted a report under title of "Report of Special Committees to the Board of Technical Advisers, International Joint Commission, Re: Dredging on Strawberry Island," dated July 23, 1948. This information was supplemented by a report, dated February 1, 1949, prepared by the U. S. fieldstaff.

The special subcommittee report indicates that the presence of Strawberry Island and surrounding shoals help to prevent strong northeast winds from blowing contaminated water from the polluted zone along the United States shore across into the West Channel. While this danger becomes less serious if the pollution along the United States side is diminished, it was agreed that it is of importance that Strawberry Island be maintained as a barrier against the possibility of such an occurrence.

Since the shores of Grand Island are clay of geological origin, whereas Strawberry Island consists of sand and gravel apparently deposited by the river itself, the report states that this indicates a tendency to build up the island rather than to wash it away. It was concluded that dredging of the interior of Strawberry Island under conditions specified in the present permit would not alter the currents in the river and thereby would not contribute to the pollution of the water in the West Channel of the Niagara River.

The information submitted by the technical staff contained historical records, dredging permits and records, and maps which supported the subcommittee's conclusion.

The Board of Technical Advisers on February 1, 1949 approved the "Report of Special Committees" and "Information Supplemental to Report," and adopted the following resolution:

"WHEREAS, the International Joint Commission has assigned to the Board of Technical Advisers the task of determining if and to what extent "the continued dredging operations in the Niagara River may result in polluting the waters of the Niagara River (West Channel) in such a way as to endanger the health of citizens of Niagara Falls and other residents of that area.", such dredging operations in question being in the interior of Strawberry Island and being conducted under authority of a permit of the Corps of Engineers, Department of the Army, dated May 5, 1947; and

"WHEREAS, a Subcommittee was appointed by the Commission to assist in the assignment, and said subcommittee has deliberated and has submitted a "Report of Special Committees to the Board of Technical Advisers, International Joint Commission, re: Dredging of Strawberry Island" under date of July 23, 1948; and

"WHEREAS, the United States Technical Staff has submitted "Information Supplemental to Report of Special Committees" dated February 1, 1949, this information having been collected with the assistance of the Canadian Technical Staff, the State Department of Health of New York, the District Engineer, Buffalo District, Corps of Engineers, the U. S. Lake Survey, and others, and such "Information Supplemental to Report" having been presented at the present meeting; and

"WHEREAS, as a result of its examination of the Report of Special Committees and the Information Supplemental to Report, the Board is convinced that all reasonable investigations have been completed; and

"WHEREAS, the Permit dated May 5, 1947, provides "(k) That this authorization covers only the excavation of material in the interior of the said island within the limits as specified on the map attached hereto. (l) That the permittee shall make provisions at his own expense and satisfactory to the said District Engineer to prevent erosion of the shoreline of said island, or the occurrence of any condition that might disturb the hydraulic regimen of said river, and that the construction of such works therefor as the said District Engineer may require shall precede dredging operations or follow such order as he may direct in writing"; and

"WHEREAS, it is the opinion of the Board, concurred in by the New York State representatives on the Board, that the dredging now completed or immediately contemplated under the terms of the Permit dated May 5, 1947, will not have an adverse effect on the waters of the Niagara River west of Grand Island.

"WHEREAS, no further activity is contemplated on the part of the Board, its subcommittee or the United States and Canadian technical staffs in regard to Strawberry Island dredging; and

"NOW, THEREFORE, BE IT RESOLVED, that the report of the subcommittee entitled "Report of Special Committees to the Board of Technical Advisers, International Joint Commission, Re: Dredging on Strawberry Island" dated July 23, 1948, and the "Information Supplemental to Report of Special Committees" presented by the United States Technical Staff and dated February 1, 1949, be approved and that copies of said Report and Information Supplemental to Report be forwarded by the United States and Canadian Board Chairmen to the United States and Canadian members of the Commission."

# CHAPTER V

# USES OF BOUNDARY WATERS

"Look beneath the surface let not the several
quality of a thing nor its worth escape thee."

- Meditations IV

The pollution of boundary waters is of major significance because of the multiplicity of purposes for which these waters are utilized and the resulting conflict between these uses. Article VIII of the treaty between the United States and Great Britain relating to boundary waters, signed January 11, 1909, states:

> "The following order of precedence shall be observed among the various uses enumerated hereinafter for these waters, and no use shall be permitted which tends materially to conflict with or restrain any other use which is given preference over it in this order of precedence:
>
> (1) Uses for domestic and sanitary purposes,
> (2) Uses for navigation, including the services of canals for the purpose of navigation,
> (3) Uses for power and for irrigation purposes."

This order of precedence should be noted in that domestic and sanitary uses, which are so closely related to public health, are given priority over all other purposes. It is also significant that other water needs, such as industrial, recreational, and support of fish and wildlife, which have come into prominence in the intervening years, are not specifically cited in the treaty. It is recognized, and rightly so, that these waters have now come to serve this expanded category of uses. Irrespective of these needs, the treaty requires that boundary waters shall not be polluted on either side to the injury of health or property on the other.

These waters constitute natural resources which have been developed to a high degree by both countries. If these resources are to be conserved for the greatest public benefit, their many and varied usages must be appraised. These are discussed herein.

## DOMESTIC WATER SUPPLY

Approximately one million persons, residing in some 40 communities, use the connecting waters from Lake Erie to Lake Ontario as a source of domestic water supply. Total water pumpage is about 220 million U. S. (180 million Imperial) gallons per day. Details of major public water supply sources are given in table 9.

Table 9

## MUNICIPAL WATER SUPPLY SOURCES

| Municipality | Source | Estimated Population Served 1948 - 1949 | Daily Consumption M.G.D. | Water Treatment |
|---|---|---|---|---|
| United States | | | (U.S. Gal.) | |
| Wanakah, N. Y. | Lake Erie | 5,000 | 0.35 | F, C, TO |
| Metropolitan Buffalo area served by Western New York Water Company | Lake Erie | 150,000 | 20.0 | F, C, TO |
| Buffalo, N. Y. | Lake Erie | 607,200 | 135.0 | F, C |
| Town of Grand Island, N. Y. | Niagara River, West Channel | 400 | 0.06 | F, C, TO |
| Tonawanda, N. Y. | Niagara River, East Channel | 13,000 | 3.5 | F, C, TO |
| North Tonawanda, N. Y. | Niagara River, East Channel | 20,300 | 6.0 | F, C, TO |
| Lockport, N. Y. | Niagara River, East Channel | 28,000 | 7.0 | F, C, TO |
| Niagara Falls, N. Y. | Niagara River, East Channel | 110,000 | 40.0 | F, C, TO |
| Wilson, N. Y. | Lake Ontario | 1,600 | 0.10 | F, C |
| TOTAL | | 935,500 | 212.0 | |
| Canada | | | (Imp. Gal.) | |
| Crystal Beach, Ont. | Lake Erie | Winter 1,300 | 0.40 | F, C |
| | | Summer 22,000 | 1.2 | |
| Fort Erie, Ont. | Upper Niagara River | 10,600 | 1.0 | C |
| Niagara Falls, Ont. | Welland River | 37,300 | 5.5 | F, C |
| Chippawa, Ont. | Niagara Falls Filtered Supply | 1,600 | 0.20 | C |
| Niagara, Ont. | Lower Niagara River | 1,900 | 0.26 | F, C, TO |
| TOTAL | | 52,700 | 7.4 | |

| | |
|---|---|
| F | Coagulation, Sedimentation, Filtration |
| C | Chlorination |
| TO | Taste and Odor Control |

The sources of supply serve all the major communities bordering the boundary waters as well as Lockport, some 20 miles distant. As the water supply of each municipality is affected by pollution introduced upstream, it is of significance that all the municipalities listed in table 9 have been forced to complete water treatment. It will be noted in most cases that treatment has been augmented by taste and odor control. This is necessary because chlorophenolic tastes and odors occur when these phenol-bearing waters are disinfected with chlorine. More recently treatment with chlorine dioxide has greatly reduced these taste and odor difficulties.

Four major water intakes in the East Channel have been located in the westerly portion of this stream in an effort to avoid the polluted zone along the easterly shore. The location of new intakes in the upper Niagara River also has been influenced by pollution originating in Buffalo and subsequently following the East Channel. An extension of the Niagara Falls, New York, water intake from the east branch to the International Branch of the West Channel at the downstream end of Grand Island is now under way. Similarly, plans are being developed to construct new intakes to serve an extended area to the east of the Niagara River. The sources of supply are likely to be Lake Erie, or the waters of the west branch at the upstream end of Grand Island, rather than the waters of the nearer east branch.

## SANITARY PURPOSES

The major portion of the water pumped for domestic consumption is returned to the boundary waters as sewage, either treated or untreated. This daily sewage flow amounts to about 230 million U. S. (190 million Imperial) gallons from nearly 900,000 persons. Sewer outfalls are widely distributed along the boundary waters and their tributaries, but the major portion of these wastes is discharged from the metropolitan areas of Buffalo, the Tonawandas, Niagara Falls in New York and from Niagara Falls in Ontario.

## NAVIGATION

Both passenger and freight vessels navigate the east end of Lake Erie, with freight and small pleasure craft utilizing the Black Rock Canal and the upper Niagara River. The lower Niagara River is used in the quiet portion by one passenger vessel.

To marine interests, Buffalo is becoming known as a shallow port because its ruling depth of 21 feet will not allow ships of greater draft to enter the harbor. There have been increasing difficulties, also, in maneuvering the larger lake vessels within the narrow, winding confines of the Buffalo River. While these factors tend to decrease navigation into the port, the City of Buffalo is contemplating creation of a Port Authority to solve these navigation problems. Additional dredging to depths of 22 and 23 feet is already under way, and several plans have been proposed to reduce the number of bends in the Buffalo River.

The extent of navigation on these waters is reflected by the following figures. During the 1947 navigation season, a total of 15,900 vessel passages were made in and out of the Port of Buffalo, carrying a total cargo of over 20,000,000 tons. The number of crew members on these passages approximated 523,000 persons. In addition, there were about 1,875 recreational craft entering and departing Buffalo Harbor, carrying a total of about 6,600 passengers.

In 1948 a total of over 5,300 vessels passed through the Black Rock Canal and Locks. The net tonnage was in excess of 4,200,000 tons, with crew members on the registered vessels totaling 42,000 persons. This does not include the crew members on over 2,700 unregistered vessels. Passengers carried through the canal were about 7,100 persons.

Many of the vessels passing through the Black Rock Locks continue through the New York State Barge Canal System. During the 1949 navigation season the freight carried by vessels through the canal was estimated at 535,000 tons. This tonnage was carried primarily by tug-towed barges. Crew members on the tugs and barges totaled about 6,500.

One passenger vessel uses the lower Niagara River from Queenston into Lake Ontario and carries about 250,000 persons during a summer season.

The disposal of sewage, refuse, oil, and ballast and bilge water from vessels is important, especially in restricted areas near sources of public water supply or near bathing beaches. It may also affect the potable water supply of other vessels.

## POWER AND IRRIGATION

The use of the boundary waters for power and irrigation was listed third in the order of precedence in the Treaty of 1909. The treaty limited the daily diversion of water from above Niagara Falls for power development to 56,000 c.f.s; 20,000 c.f.s. for use on the United States side, and 36,000 for use on the Canadian side.

The first successful development of power from the Falls dates from 1877 when the Niagara Falls Hydraulic Power and Manufacturing Company constructed a canal on the United States side from above the Falls to the edge of the gorge where two power plants were built. Two more plants were constructed on the same site in 1918 and 1921, and these four plants are now known as the Schoellkopf Station of the Niagara Falls Power Company. Just prior to 1900 a second development on the United States side was begun. Two plants were constructed about a mile and one-half above the Falls utilizing a short intake forebay, deep wheelpits for power units, and a long tailrace tunnel which discharged downstream into the Maid of the Mist pool. These plants are known today as the Edward Dean Adams Station of the Niagara Falls Power Company.

Power development on the Canadian side began in 1893 with a small installation by the International Railway Company. Major construction started early in 1900 when the Canadian Niagara Power Company, the Ontario Power Company, and the Electrical Development Company built power plants adjacent to the Falls. The latter two plants are known today as the Ontario and Toronto Plants, respectively, of the Hydro Electric Power Commission of Ontario. The design of the Canadian Niagara Power Company's station and the Toronto Plant are similar to that of the Edward Dean Adams Station, but the third utilizes conduits and penstocks to convey the water to the power generator units which are located on the bank of the Maid of the Mist pool.

The Queenston-Chippawa development was constructed between 1916 and 1921. This development by the Hydro Electric Power Commission of Ontario consisted of intake works at the mouth of the Welland River, reversing the flow in a section of the river, dredging the bed of the river, and construction of a canal from Montrose to Queenston where the power house was located. Thus, the discharge of the Welland River combines with Niagara

River water diverted at Chippawa, and the combined flow enters the lower river by way of the power canal. This power plant showed marked advancement over earlier developments and is the only one utilizing the full head available from the river. It is known as the Queenston Plant of the Hydro Electric Power Commission.

The total output of the present power installations on the two sides of Niagara Falls is listed below:

| | |
|---|---|
| United States | |
| Niagara Falls Power Company | |
| Schoellkopf Station | 334,800 Kilowatts |
| Edward Dean Adams Station | 80,000 Kilowatts |
| Canada | |
| Hydro Electric Power Commission | |
| Ontario Plant | 130,000 Kilowatts |
| Toronto Plant | 110,000 Kilowatts |
| Queenston Plant | 320,000 Kilowatts |
| Canadian Niagara Power Company | |
| Wm. B. Rankine Station | 74,600 Kilowatts |
| TOTAL | 1,049,400 Kilowatts |

Several of the above units were not in use in the 15-year period prior to World War II because water for diversion purposes was not made available. Due to that emergency, however, agreements between the two Governments were made during the course of the war to increase diversion of water from the upper river by 30,500 c.f.s. The United States was to use 12,500 c.f.s. and Canada 18,000 c.f.s. All of the available power units have been in use since that time.

A new treaty providing for diversion of additional water for power purposes, as noted in the previous chapter, now awaits ratification by both Governments. This treaty provides an estimated average diversion of 131,000 c.f.s. to be allocated equally to both countries. Both

United States and Canadian power agencies are studying plans for redeveloping power installations to utilize this additional water diversion as well as the full head available at the Falls.

There are no irrigation projects on the Lake Erie-Lake Ontario Section of the boundary waters.

## INDUSTRIAL USES

Industry uses these waters for process, steam power, cooling, and sanitary purposes. The water so used, exclusive of steam power plants, amounts to nearly 500 million U. S. (420 million Imperial) gallons per day. Of this daily amount, 155 million U. S. gallons are pumped from Lake Erie, 124 million U. S. gallons from the Buffalo River, and about 183 million U. S. gallons from the upper Niagara River. No industries in the area take water from the lower Niagara River or Lake Ontario.

About 60% of this industrial supply is returned directly to the boundary waters, while approximately 30% is discharged into the principal tributaries through which the wastes find their way to the boundary waters. The remaining portion of the industrial supply is discharged to municipal sewer systems.

Industries use a total of about 20 million (U. S.) gallons per day of water from municipal supplies. This water is used largely for drinking and sanitary purposes and, in general, ultimately reaches the boundary waters by way of the municipal sewers.

The Buffalo River, on which are located five major industries, receives large quantities of industrial wastes. Under conditions of low flows in the river as discussed in Chapter IV, the river becomes grossly polluted and septic action takes place. To alleviate this condition, the industries concerned have entered into an agreement with the Buffalo Sewer Authority to participate in a project to pump water from Lake Erie to the industries for cooling purposes. Since industries require from 120 to 150 million (U. S.) gallons per day, this volume of clean, cool, and alkaline water will have many benefits. It is anticipated that this amount of water will create sufficient flow in the Buffalo River to prevent concentration of wastes, as well as to provide the industries with a cleaner and cooler water.

The cost of the Lake Erie Cooling Water Project is estimated at $5,500,000. The general proposal has been approved and accepted by each of the five participating industries as well as the Buffalo Sewer Authority. However, problems relating to the financing of the project have not yet been fully solved.

## RECREATIONAL USES

The use of the boundary waters in the Lake Erie-Lake Ontario Section for bathing purposes is not extensive. The shore along Lake Erie on the Canadian side is widely used for bathing. Crystal Beach is the best known and offers both commercial and public bathing facilities. On the upstream end of Grand Island in the upper river, the State of New York maintains a public bathing beach in Beaver Island State Park. None of the municipalities maintain public beaches. Swimming along the waterfront of residential property is done on both the Canadian and United States shores of Lake Ontario. Pollution, especially along the United States side, has interfered with development of areas suitable for bathing.

The waters in the Buffalo area and in the lower Niagara River below Lewiston and Queenston are widely used for pleasure boating. Some 1,800 small power boats use the waters in the eastern end of Lake Erie and the upper Niagara River. About 160 of these boats are licensed on the Canadian side, while 800 are registered in Buffalo as being 16-foot length or over. Approximately 600 small power craft ply the lower river, 400 being registered in United States and 200 in Canada.

FISH AND WILDLIFE

Commercial and sport fishing are practiced in the waters from the eastern part of Lake Erie to Lake Ontario, except in the sections of rapid flow in the Niagara River. The value of the Niagara River as a spawning area is considerable, there being large quantities of young fish in both the upper and lower river. The fact that Buffalo and other centers of population are adjacent to the area leads to wide recreational use of these waters for fishing. Poundage is secondary to the enjoyment of the sport.

Sport fishing in the eastern end of Lake Erie and the upper Niagara River is important. Species taken include blue and yellow pike, yellow perch, small and large mouth bass, whitefish, white bass, bullheads, northern pike, muskellunge, sturgeon, rock bass, and sunfish. Many man-days of fishing and many thousands of dollars are expended for this sport. Ice fishing for blue and yellow pike and yellow perch has been unusually productive in recent years. The lower Niagara River in the gorge is not suitable for angling, but the lower quiescent reaches are an important sport fishing ground for blue and yellow pike. Perch is predominant near the mouth of the river in Lake Ontario. Over a long period sport fishing in this area has increased.

Commercial fishing in these boundary waters is affected by regulations limiting the fishing methods that may be employed. On the United States side the netting of all fish except minnows is prohibited in the Niagara

River, within five miles from the head of the river in Lake Erie and one-half mile from the Lake Erie shore elsewhere, and within one mile of the mouth in Lake Ontario and one-half mile from the Lake Ontario shore elsewhere. On the Canadian side, nets are prohibited in any river, creek, or within 1,000 yards of either side of the entrance thereto.

While Lake Erie is the most productive of the Great Lakes for commercial fishing, it is estimated that only about 3% of the bulk of the United States catch is taken in this area. Blue pike, ciscoes, and whitefish are the predominant species caught. Approximately 50,000 pounds of fish, worth about $7,000, are taken commercially by United States and Canadian interests from the eastern end of Lake Erie under investigation. About three-fourths of this catch is made in United States waters. Most of Lake Ontario is too deep for commercial fishing, but the shallow waters within a 15 mile radius of the Niagara River outlet are fairly productive. An estimate of about 130,000 pounds is caught annually in this area, with a value of about $20,000. Nearly all this amount is caught by United States licensed fishermen, and this comprises about half the total Lake Ontario catch on the United States side. As in Lake Erie, whitefish, ciscoes, and blue pike make up the bulk of the catch.

## WILDFOWL

The Niagara River flyway is considered one of the most important in New York State or the Province of Ontario. The area is therefore used for hunting of ducks and geese. Certain areas on both sides of the river, including Goat Island, are closed to hunting, but a considerable amount occurs along the eastern end of Lake Erie and in the open areas of the Niagara River.

No population census of migratory wildfowl has been made. Predominant types of ducks found in this area include the Black, the Mallard, and the Golden Eye. There is a substantial population of Black ducks on Goat Island, providing a tourist attraction. Especially during the spring migratory season the Niagara River flyway is used by the Canada goose.

## LEGISLATION

Administrative authority for remedial measures in pollution control is centered in the legislation enacted by various levels of governments in both countries. The several Federal, state, provincial, and municipal laws applicable to pollution control are discussed herewith.

### Federal Legislation - United States

The United States Government now exercises pollution control mainly through four acts of legislation. The first of these is embodied in the provisions of Section 13 of the "Laws for the Protection and Preservation of the Navigable Waters of the United States" as included in the River and Harbor Act, approved March 3, 1899. This law prohibits the deposit of "any refuse matter of any kind or description whatever other than that flowing from streets and sewers and passing therefrom in a liquid state, into any navigable water of the United States or into any tributary of any water from which the same shall float or be washed into such navigable water."

The "Oil Pollution Act of 1924" deals specifically with deposition of oils from vessels into coastal or tidal navigable waters.

The Interstate Quarantine Regulations, Section 72.121, Part 72, Title 42, Code of Federal Regulations, prohibits the discharge of sewage, ballast or bilge water from vessels while operating on fresh water lakes and rivers within areas adjacent to domestic water intakes, as designated by the Surgeon General of the Public Health Service.

The most recent legislation enacted by the U. S. Government is Public Law 845, known as the "Water Pollution Control Act." This law, enacted June 30, 1948, is designed to "recognize, preserve and protect the primary responsibilities and rights of the States in controlling water pollution, to support and aid technical research to devise and perfect methods of treatment of industrial wastes which are not susceptible to known effective methods of treatment, and to provide Federal technical services to State and interstate agencies and to industries, and financial aid to State and interstate agencies and to municipalities, in the formulation and execution of their stream pollution abatement programs." The authority and responsibilities relating to this Act are vested in the Public Health Service and the Federal Works Administration. The Public Health Service shall "in co-operation with other Federal agencies, with State water pollution control agencies, and interstate agencies, and with municipalities and industries involved, prepare or adopt comprehensive programs for eliminating or reducing the pollution of interstate waters and tributaries thereof and improving the sanitary condition of surface and underground waters."

Federal Legislation - Canada

There is no Federal legislation in Canada which is concerned with pollution of water per se. There are, however, certain statutes which indirectly deal with the question of pollution and might, under appropriate circumstances, be successfully invoked.

The "Navigable Waters Protection Act," enacted in 1927, prohibits the throwing or depositing of "any sawdust, edgings, slabs, bark or rubbish, of any description whatsoever into any river, stream or other water, any part of which is navigable or which flows into any navigable water." It further prohibits the throwing or deposition of "any stone, gravel, earth, cinders, ashes or other material or rubbish liable to sink to the bottom in any navigable non-tidal waters of Canada where there are not at all times at least eight fathoms of water."

The "Fisheries Act," enacted in 1927, prohibits the discharge of ballast, coal ashes, stones, lime, chemical substances or drugs, dead or decaying fish, and other deleterious substances either on shore, between the high and low water levels, or into "any water frequented by fish, or that flows into such water, nor on ice over either such waters."

The "Migratory Birds Convention Act," enacted in 1927, prohibits the deposit or discharge of "oil, oil wastes, or deleterious substances .... in any water frequented by migratory wildfowl, or that flows into such water, nor on ice over either of such waters."

Section 5(f) of the "National Health Act" of Canada, enacted in 1944, states that the Minister of National Health and Welfare shall enforce "any rules or regulations made by the International Joint Commission, promulgated pursuant to the treaty .... so far as the same relate to public health."

The Criminal Code of Canada, Section 221, defines a common nuisance as "an unlawful act or omission to discharge a legal duty, which act or omission endangers lives, safety, health, property or comfort of the public, or by which the public are obstructed in the exercise or enjoyment of any right common to all His Majesty's subjects. R.S., c.146, s.221." Appropriate penalties are prescribed for anyone guilty of a common nuisance.

State of New York

Article V of the Public Health Law heretofore has governed the prevention of pollution of the waters of the state by requiring approval of plans and a permit from the State Commissioner of Health for the discharge of sewage or industrial wastes. One section of this law empowers the Commissioner of Health to issue orders requiring abatement of pollution when sewage or waste discharges are in quantities injurious to public health or when the conditions constitute a public nuisance. However, to be valid any such order issued by the Commissioner of Health must also be countersigned by both the Governor and Attorney General.

To improve water pollution control in the state, Chapter 666 of the Laws of 1949, constituting a new Article VI of the Public Health Law, was enacted to amend the Public Health Law, the Code of Criminal Procedure and the State Finance Law. This new law declares it to be the public policy of the state "to maintain reasonable standards of purity of the waters of the state consistent with public health and public enjoyment thereof, the propogation and protection of fish and wildlife, including birds, mammals and other terrestial and aquatic life, and the industrial development of the state, and to that end require the use of all known available and reasonable methods to prevent and control the pollution of the waters of the state of New York." Further, the new law declares its purpose to be to "Safeguard the waters of the state from pollution by: (a) preventing any new pollution, and (b) abating pollution existing when this law is adopted, under a program consistent with the declaration of policy above stated in the provisions of this article."

A Water Pollution Control Board is created by this new law, within the Department of Health and composed of the Commissioners of the State Departments of Health, Conservation, Agriculture and Markets, Commerce, and the Superintendent of Public Works. The State Commissioner of Health is chairman of this Board. An executive secretary, a duly qualified sanitary engineer, acts as administrative agent for the Board. This Board is vested with broad authority, power, and duties to require approval of plans and permits for all sewage or waste discharges; to adopt rules and regulations governing hearings, permits, and other procedures; and to classify all waters of the state and assign standards of quality to them, after public hearings to determine the best usage of such waters in the public interest. After a water has been classified and assigned standards of quality, the Board may issue orders requiring the discontinuance of any discharge of sewage or waste which contravenes the established standards. The Board is also authorized to conduct studies and research relating to pollution abatement and to encourage voluntary cooperation in pollution control.

As time will be required to make surveys needed for the classification of state waters, the act provides for the repeal or the continuance until April 1, 1959 of existing health laws relating to stream pollution. The existing conservation law will empower the Conservation Department to take action when pollution results in fish kills until the law is replaced on January 1, 1960 by Article VI of the Public Health Law.

New York State is by legislative action a member of the following three interstate compacts for the control of pollution, which have been authorized by the Congress of the United States and endorsed by the legislatures of the respective member states.

1. Interstate Sanitation Commission representing the states of New York, New Jersey, and Connecticut
2. Ohio River Valley Water Sanitation Compact between the states of Illinois, Indiana, Kentucky, New York, Ohio, Pennsylvania, Virginia, and West Virginia
3. New England Interstate Water Pollution Control Compact between the states of New Hampshire, Vermont, Maine, Rhode Island, Connecticut, and New York

In addition, legislative action by the states of New York, Pennsylvania, New Jersey and Delaware resulted in the formation of the Interstate Commission on the Delaware River (INCODEL) which functions through cooperative agreement of the member states.

As a signatory member of these three compacts and of the cooperative arrangement represented by INCODEL, New York State has agreed to carry out a pollution abatement program consistent with the minimum requirements of such compacts or agreements.

Province of Ontario

The Public Health Act of Ontario contains several sections dealing with pollution. Section 97 reads, "The Department (of Health) shall have the general supervision of all springs, wells, ponds, lakes, streams or rivers used as a source for a public water supply or for agricultural, domestic or industrial purposes with reference to their purity, together with the waters feeding the same, and shall examine the same from time to time when the necessity for such examination arises, and inquire what, if any, pollution exists and the causes thereof.

"The Department (of Health) may inquire into and hear and determine any complaint made by or on behalf of a riparian proprietor entitled to the use of water, that any industrial waste or any other polluting material of any kind whatsoever which either by itself or in connection with other matter may corrupt or impair the quality of the water or may render such water unfit for accustomed or ordinary use has been placed in, or discharged into such water, or placed or deposited upon the ice thereof, or placed or suffered to remain upon the bank or shore thereof."

Section 98 of this same act prohibits the discharge of pollution and reads as follows: "No garbage, excreta, manure, vegetable or animal matter or filth shall be discharged into or be deposited in any of the lakes, rivers, streams or other waters in Ontario or on the shores or banks thereof, and no industrial or other wastes, dangerous or liable to become dangerous to health or to become a nuisance, or to impair the safety, palatability or potability of the water supply of any municipality or riparian owner, shall be discharged into or be deposited in any of the lakes, rivers, streams, or other waters of Ontario, or on the shores or banks thereof.

"The owners and officers of boats and other vessels plying upon any such lake, river, stream or other water shall so dispose of the garbage, excreta, manure, vegetable or animal matter or filth upon such boats or vessels as not to create a nuisance or enter or pollute such lake, river, stream or other water."

Section 100 of "The Public Health Act" prohibits pollution of public water supplies. "No sewage, drainage, domestic, commercial or factory refuse, excremental or other polluting matter of any kind whatsoever which either by itself or in connection with other matter corrupts, pollutes or impairs or may corrupt, pollute or impair the quality of the water of any source of public water supply for domestic use in any municipality, or which renders or may render such water injurious to health shall be placed in, deposited on, or discharged into the waters, or placed or deposited upon the ice of any such source of water supply, or be placed, deposited or discharged, or suffered to remain in, on or upon the bank or shore of any such source of water supply, or in, or upon any lands adjacent to any such source, nor shall any person bathe or swim in the water of any such source of water supply."

The approval of the Department of Health is required before work is undertaken on any public waterworks or sewerage system. Similarly, the Department has authority to require that any waterworks or sewerage system be constructed, extended, enlarged or altered.

An amendment to "The Rivers and Lakes Improvement Act" passed in 1949 reads as follows: "Section 30 of The Lakes and Rivers Improvement Act is repealed and the following substituted therefor:

"In this section 'mill' means a plant or works in which logs or woodbolts are processed and includes a saw mill, a pulp mill, and a pulp and paper mill.

"Where in an action or proceeding a person claims, and but for this section would be entitled to, an injunction against the owner or occupier of a mill for an injury or damage, direct or consequential, sustained by such person, or for any interference directly or indirectly with any rights of such person as riparian proprietor or otherwise, by reason or in consequence of the throwing, depositing, or discharging, or permitting the throwing, depositing or discharging of any refuse, sawdust, chemical substance or matter from the mill or from it and other mills into any lake or river, or by reason or in consequence of any odour arising from any such refuse, sawdust, chemical substance or matter so thrown, deposited or discharged or so permitted to be thrown, deposited or discharged, the court or judge may: --

(a) refuse to grant an injunction if it is proved that having regard to all the circumstances and taking into consideration the importance of the operation of the mill to the locality in which it operates and the benefit and advantage, direct and consequential, which the operation of the mill confers on that locality and on the inhabitants of the locality, and weighing the same against the private injury, damage or interference complained of, it is on the whole proper and expedient not to grant the injunction; or

(b) grant an injunction to take effect after such lapse of time or upon such terms and conditions or subject to such limitations or restrictions as may be deemed proper; or

(c) in lieu of granting an injunction, direct that the owner or occupant of the mill take such measures or perform such acts to prevent, avoid, lessen or diminish the injury, damage or interference complained of as may be deemed proper.

"Nothing in subsection 2 shall affect any right of the person claiming the injunction to damages against the owner or occupier of the mill for any such injury damage or interference.

"Where damage from the same cause continues the person entitled to the damages may apply from time to time in the same action or proceeding for the assessment of subsequent damages or for any other relief to which by subsequent events he may from time to time become entitled.

"This section shall apply whether the injury, damage or interference is or is not a continuing one, and whether the person claiming the injunction in the action or proceeding is a plaintiff or is a defendent proceeding by way of counter-claim.

"Section 30 of 'The Lakes and Rivers Improvement Act,' as re-enacted by subsection 1 of this section, shall apply to every action or proceeding in which an injunction is claimed in respect of any of the matters mentioned in such section, including every action or proceeding in which an injunction has been granted and in which any appeal is pending."

Municipal Regulations

Municipalities are authorized to enact regulations or by-laws dealing with such local matters as control of pollution, restrictions on the use of sewers, setting rates for sewer service rates, and financing.

# CHAPTER VI

# WATER-BORNE DISEASES

> "Public health is purchasable. Within natural limitations any community can determine its own death rate."
>
> - Herman M. Biggs

The incidence of water-borne diseases has been utilized for many years to evaluate the effects of sewage pollution. Statistical data on these diseases are available for long periods. For purposes of this investigation these records have been confined to typhoid fever and other enteric diseases. These diseases have been associated conspicuously with public water supplies, either in the form of actual outbreaks or as potential menaces.

## EPIDEMIOLOGICAL STUDIES

The findings of the 1913 survey, as recorded in the Progress Report of the International Joint Commission, dated January 16, 1914, have been reviewed. At that time two special reports were presented as appendices: "Sanitary Conditions in Cities and Towns Situated on the United States Side of the Boundary Waters with Special Reference to Typhoid Fever," and "Typhoid Fever Statistics and Some Sanitary Facts Affecting its Undue Prevalence in Ontario." Typhoid fever death rates were given for various municipalities along the boundary waters. The excessive prevalence of this disease on the United States side, especially in the winter and spring months, was attributed in greatest measure to the sewage pollution of the interstate and international waters used as sources of public water supply. It was also stated that in Ontario the typhoid rates were excessive in most parts of the province, and they were highest of all in those municipalities situated on the international waters. Their studies led the investigating authorities to conclude that high typhoid rates in cities and towns were closely related to sewage pollution of water supplies.

Comparable statistics for 1948, presented in table 10, show that typhoid fever has been virtually eliminated. No typhoid fever outbreak attributable to a public water supply has occurred along the Niagara Frontier during the past 15 years.

Table 10 -- TYPHOID FEVER MORTALITY

Total Deaths and Death Rates per 100,000 Population

| Municipality | 1913 | | 1920 | | 1930 | | 1940 | | 1948 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | No. | Rate | No. | Rate | No. | Rate | No. | Rate | No. | Rate |
| State of New York | 1,018 | 10.6 | 371 | 3.5 | 148 | 1.2 | 26 | 0.2 | 6 | <0.05 |
| Lackawanna | 0 | 0 | 1 | 5.5 | 1 | 4.2 | 0 | 0 | 0 | 0 |
| Buffalo | 68 | 15.4 | 26 | 5.1 | 11 | 1.9 | 0 | 0 | 0 | 0 |
| Tonawanda | 3 | 34.0 | 2 | 19.6 | 0 | 0 | 0 | 0 | 0 | 0 |
| North Tonawanda | 2 | 15.5 | 3 | 19.2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Lockport | 13 | 70.6 | 1 | 4.7 | 2 | 8.6 | 1 | 4.1 | 0 | 0 |
| Niagara Falls | 10 | 26.4 | 4 | 7.8 | 0 | 0 | 0 | 0 | 0 | 0 |
| Lewiston | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Youngstown | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Province of Ontario | 446 | 16.7 | 203 | 7.0 | 76 | 2.3 | 26 | 0.7 | 6 | 0.1 |
| Fort Erie | - | - | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Chippawa | - | - | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Niagara Falls | 8 | 66.6 | 3 | 20.3 | 1 | 5.4 | 0 | 0 | 0 | 0 |
| Welland | 8 | 123.6 | 2 | 20.6 | 1 | 9.9 | 0 | 0 | 0 | 0 |
| Niagara | - | - | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

There have been no deaths from typhoid fever since 1940 in the places noted in table 10 except for two in Buffalo in 1944, and two in Buffalo and one in Niagara County in 1942. Typhoid fever deaths have been allocated to place of origin of disease since 1932.

The 1913 report refers to the prevalence of "winter cholera", a local name for unclassified diarrheal diseases prevalent in the area. Cases of water-borne enteric diseases reported to health officials have been restricted to typhoid fever, bacillary and amoebic dysentery, and diarrhea of the newborn. Hence, unclassified diarrheal diseases cannot be subjected to statistical study, except when the number of such cases is sufficient to disclose the occurrence of outbreaks.

An outbreak of water-borne gastroenteritis occurred in Niagara Falls, New York, in 1933, involving approximately 10,000 cases. No cases of typhoid fever or bacillary dysentery were reported. This outbreak was due to a lapse in effective chlorination of the public water supply during a period when the chlorine dose was not adjusted sufficiently and quickly enough to compensate for a very sudden, tenfold increase in chlorine demand of the raw water. Investigation disclosed that an ice jam in the Niagara River and in Buffalo Harbor had led to retention of polluted water. A sudden disintegration of the ice jam following a rapid thaw accompanied by heavy rainfall, led to the flushing of this heavily polluted water into the upper Niagara River. This episode again focuses attention upon the basic importance of meteorological conditions and the unusual stream flow characteristics in the Niagara River in determining the distribution of polluted water, as discussed elsewhere in this report.

The previous report contained no data on diseases attributable to swimming in the Niagara River. Since that time no statistics have been recorded on this subject.

## EFFECT OF WATER PURIFICATION

The fact that water-borne typhoid fever has virtually disappeared must not be construed to mean that the pollution of sources of water supply has diminished to the same extent. Several factors have contributed to this reduction. The installation and effective operation of modern water treatment plants is of major importance. The diminishing number of typhoid carriers discharging pathogenic micro-organisms into sewage reaching these waters is also of prime importance. The treatment of sewage from Buffalo and other municipalities has reduced the bacterial pollution received by the river despite a steadily increasing contributory population. All of these factors have made it possible to avoid outbreaks of water-borne diseases even under adverse circumstances. Pollution by industrial wastes has greatly complicated water purification. Chlorination for disinfecting purposes is rendered more difficult because of the fluctuating degree of pollution. Complex taste and odor problems have been created by industrial waste pollution. The magnitude of these problems has focused attention on the superior quality of water in the westerly portion of the upper river and is prompting extension of water supply intakes on the United States side into these waters.

Epidemiological data as to water-borne typhoid fever was given major consideration in the 1913 investigation because the prevalence of this disease was the best criterion for determining the public health effect of the pollution of the waters. Under present conditions careful consideration must be given to the growing problem of producing potable water of attractive physical character in an economical manner. Yardsticks, other than water-borne diseases, must also be utilized in appraising the significance of pollution of the Niagara River.

# CHAPTER VII

## SOURCE AND CHARACTER OF POLLUTION

"The shape of things tomorrow is dependent
on the shape of things today."

- The Harvard Fund Council

Pollution in these boundary waters originates principally from domestic and industrial wastes from sources located along the shores. These wastes are of primary importance since their effects are imposed directly on the boundary waters. Sources of pollution on tributary streams were also studied to ascertain if the effects of those wastes were transmitted to the boundary waters.

Data on domestic wastes were secured from complete sampling and gaging studies conducted at two of the sewage treatment plants, and from local, state and provincial authorities.

Thirty-four industrial plants were studied during the investigation, thirty being in the United States and four in Canada. Complete sampling and gaging studies were made at eight of these thirty-four industries by the field technical staff. Industry itself conducted gaging and sampling studies at many of those industries where little information was available. Data on the wastes were reviewed and agreed to in all cases by the industry concerned.

Vessels engaged in freight and passenger traffic, particularly in the Lake Erie and upper Niagara River area, contribute pollution by their sewage and refuse. Pleasure craft also ply these boundary waters, but it is not believed they contribute a serious pollution load.

## DOMESTIC WASTES

All of the larger municipalities are sewered, and in 16 out of a total of 20 municipalities, the sewage is subjected to some degree of treatment. There are also several small communities with waterworks systems, where sewers ultimately will be built. These constitute a potential pollution problem unless treatment works are also constructed. Information on the main sources of domestic sewage for this section of the boundary waters is recorded in table 11. It should be noted that the population figures do not include any equivalent for industrial wastes entering the public sewer systems.

Table 11 -- PRINCIPAL SOURCES OF DOMESTIC SEWAGE

| Municipality | Receiving Stream or Lake | Population Total (Est.1949) | Population Served by Sewers | Degree of Treatment |
|---|---|---|---|---|
| United States | | | | |
| Wanakah Sewer District, Town of Hamburg | Lake Erie | 920 | 920 | Primary |
| Mt. Vernon Sewer District, Town of Hamburg | Lake Erie | 2,500 | 2,500 | Primary |
| Woodlawn Sewer District, Town of Hamburg | Lake Erie via Rush Creek | 2,000 | 2,000 | Secondary |
| Blasdell Village | Lake Erie via Rush Creek | 3,000 | 3,000 | Secondary |
| Lackawanna City | Lake Erie via Smokes Creek | 30,000 | 30,000 | Secondary |
| Buffalo City | Upper Niagara River | 617,937 | 600,000 | Primary |
| Grand Island Sewer District No. 1 | Upper Niagara River, East Channel | 650 | 650 | Primary |
| Tonawanda City | Upper Niagara River, East Channel | 15,000 | 15,000 | Primary |

Table 11 -- PRINCIPAL SOURCES OF DOMESTIC SEWAGE (Continued)

| Municipality | Receiving Stream or Lake | Population | | Degree of Treatment |
|---|---|---|---|---|
| | | Total (Est.1949) | Served by Sewers | |
| **United States** | | | | |
| North Tonawanda City | Upper Niagara River, East Channel | 27,000 | 27,000 | None |
| Town of Tonawanda, Sewer District No. 2 | Upper Niagara River, East Channel via Two Mile Creek | 35,000 | 35,000 | Primary |
| Town of Tonawanda, Sewer District No. 3 | Upper Niagara River, East Channel via Ellicott Creek | 1,000 | 1,000 | Secondary |
| Niagara Falls City | Lower Niagara River | 92,000 | 105,450 | Primary |
| Youngstown Village | Lake Ontario | 800 | 1,500 | Primary |
| **Canada** | | | | |
| Crystal Beach Village | Lake Erie | 1,300 | 1,300 (8,000 Summer) | Secondary |
| Fort Erie Town | Upper Niagara River | 7,500 | 7,500 | Septic Tanks |
| Niagara Falls City | Lower Niagara River | 22,000 | 22,000 | None |
| Chippawa Village | Lower Niagara River via Welland River & Queenston Canal | 1,600 | 1,600 | Septic Tanks |
| Welland City | Lower Niagara River via Welland River & Queenston Canal | 16,000 | 16,000 | None |
| Stamford Township | Lower Niagara River via Welland River & Queenston Canal | 13,500 | 8,000 | Septic Tanks (Part) |
| Niagara Town | Lake Ontario | 1,900 | 1,200 (3,000 Summer) | None |

The municipalities served by sewage treatment are located along the entire stretch of boundary waters. Twelve of these treatment works are located in the United States and four in Canada. The data presented in table 11 are summarized in table 12 to show the population contributory to the various areas of the boundary waters.

Table 12 — SUMMARY OF SEWAGE COLLECTION AND TREATMENT BY AREAS

| Area | Total Population Estimate 1948-49 | Population Served | | |
|---|---|---|---|---|
| | | By Sewers Only | By Sewers and Treatment | Total Sewered |
| Lake Erie | 39,700 | - | 39,700 | 39,700 |
| Upper Niagara River | 706,400 | 27,000 | 659,300 | 686,300 |
| Lower Niagara River | 163,600 | 38,000 | 115,100 | 153,100 |
| Lake Ontario | 3,400 | 1,200 | 1,500 | 2,700 |
| Total | 913,100 | 66,200 | 815,600 | 881,800 |

Except for approximately 30,000 persons, all of the total estimated population of nearly 915,000 situated along the boundary waters are served by sewer systems. Treatment facilities are provided for about 92% of the population served by sewers. The plant of the Buffalo Sewer Authority alone serves 618,000 persons or 70% of this total. Most of these sewer systems are of the combined type with storm water and sewage carried in the same sewer. Table 12 shows a high percentage of the population being served by sewage treatment. About 5% of this population is served by plants employing secondary or biological treatment.

The total estimated volume of municipal sewage discharged to the waters of these areas is tabulated in table 13. These totals include wastes contributed by industries located within the municipalities and connected to the public sewer system.

Table 13 -- VOLUME OF MUNICIPAL SEWAGE

(Average Annual)

| Area | Volume - Million Gallons per Day | | | |
|---|---|---|---|---|
| | United States | Canada | Total - Both Sides | |
| | U. S. Gallons | Imp. Gallons | U. S. Gallons | Imp. Gallons |
| Lake Erie | 3.8 | 0.4 | 4.3 | 3.6 |
| Upper Niagara River | 127. | 0.8 | 128. | 107. |
| Lower Niagara River | 82. | 10.7 | 95. | 79. |
| Lake Ontario | 0.3 | 0.5 | 0.9 | 0.8 |
| Total | 213 | 12.4 | 228 | 190 |

Sewage Treatment Plants

The largest sewage treatment works in this area, operated by the Buffalo Sewer Authority to serve the City of Buffalo, provides primary treatment, chlorination of the effluent, separate sludge digestion, and incineration of the sludge. The City of Lackawanna plant employs secondary treatment, the effluent being discharged to Smokes Creek, a tributary of Lake Erie. The Town of Tonawanda operates two sewage treatment works, one providing biological treatment. The effluents from both plants discharge to tributaries of the upper Niagara River. The City of Tonawanda plant, providing primary treatment, discharges directly to the upper Niagara River. The treatment works of the City of Niagara Falls, New York, comprises a fine screening plant, with chlorination of the effluent during the summer months. It discharges to the lower Niagara River.

The Village of Crystal Beach on the Canadian side employs secondary treatment by activated sludge, the plant effluent being discharged to Lake Erie.

Details of the various plants are as follows:

### Wanakah Plant, New York

Operated by: Board of Sewer Commissioners, Wanakah Sewer District
Communities Served: Wanakah hamlet
Treatment: Sedimentation (Imhoff tanks), sludge drying beds, postchlorination
Design Flow: 0.12 M.G.D. (U. S.)
Present Flow: 0.115 M.G.D. (U. S.)
Design Population: 400 persons winter; 1,600 persons summer
Population Served: 920 persons
Receiving Stream: Lake Erie

### Mt. Vernon Plant, New York

Operated by: Board of Sewer Commissioners, Mt. Vernon Sewer District
Communities Served: Hamlets of Mt. Vernon, Locksley Park and Cloverbank
Treatment: Sedimentation (Imhoff tank), postchlorination with contact tank, and covered sludge drying beds
Design Flow: 0.625 M.G.D. (U. S.)
Present Flow: 0.65 M.G.D. (U. S.)
Design Population: 7,500 persons
Population Served: 2,500 persons
Receiving Stream: Lake Erie

### Woodlawn Plant, New York

Operated by: Board of Sewer Commissioners, Woodlawn Sewer District

Communities Served: Woodlawn hamlet

Treatment: Sedimentation (Imhoff tank), trickling filter, final sedimentation, postchlorination, covered sludge drying beds

Design Flow: 0.24 M.G.D. (U. S.)

Present Flow: 0.10 M.G.D. (U. S.) Dry-weather flow

Design Population: 2,400 persons

Population Served: 2,000 persons

Receiving Stream: Rush Creek, tributary to Lake Erie

### Blasdell Plant, New York

Operated by: Village of Blasdell

Communities Served: Village of Blasdell

Treatment: Bar screen, sedimentation (Imhoff tank), trickling filter, and sludge drying bed

Design Flow: 0.44 M.G.D. (U.S.)

Present Flow: 0.25 M.G.D. (U.S.)

Design Population: 4,000 persons

Population Served: 3,000 persons

Receiving Stream: Rush Creek, tributary to Lake Erie

### Lackawanna Plant, New York

Operated by: City of Lackawanna

Communities Served: City of Lackawanna

Treatment: Sedimentation (Imhoff tank), trickling filter, postchlorination, final sedimentation and covered sludge drying beds. One of the three storm-overflow pump stations is equipped with grit chamber, bar screen, comminutor, and chlorination. All other excess storm water is chlorinated and by-passed to Smokes Creek.

Design Flow: 2.5 M.G.D. (U. S.)

Present Flow: 2.7 M.G.D. (U. S.) Dry-weather flow

Design Population: 25,000 persons

Population Served: 30,000 persons

Receiving Stream: Smokes Creek, tributary to Lake Erie

### Buffalo Plant, New York

Operated by: Buffalo Sewer Authority

Communities Served: City of Buffalo

Treatment: Chlorination, sedimentation, sludge digestion, vacuum filtration, incineration

Design Flow: 150 M.G.D. (U. S.)

Present Flow: 113 M.G.D. (U. S.)

Design Population: 750,000 persons

Population Served: 600,000 persons (Exclusive of industrial waste)

Receiving Stream: Upper Niagara River

## Grand Island Plant, New York

Operated by: Town of Grand Island
Communities Served: Sewer District No. 1
Treatment: Comminutor, prechlorination, sedimentation, vacuum filtration
Design Flow: 0.14 M.G.D. (U. S.)
Present Flow: 0.06 M.G.D. (U. S.)
Design Population: 1,200 persons
Population Served: 650 persons
Receiving Stream: Upper Niagara River, East Channel

## City of Tonawanda Plant, New York

Operated by: City of Tonawanda
Communities Served: City of Tonawanda
Treatment: Grit removal, sedimentation, chlorination, separate sludge digestion and vacuum filtration
Design Flow: 3.50 M.G.D. (U. S.)
Present Flow: 3.5 M.G.D. (U. S.) Dry-weather flow
Design Population: 22,000 persons
Population Served: 15,000 persons
Receiving Stream: Upper Niagara River, East Channel

## Town of Tonawanda - Sewer District No. 2 Plant, New York

Operated by: Town of Tonawanda

Communities Served: Village of Kenmore

Treatment: Sedimentation, separate sludge digestion, sludge drying beds, pre- and postchlorination

Design Flow: 3.5 M.G.D. (U. S.)

Present Flow: 3.5 M.G.D. (U. S.)

Design Population: 35,000 persons

Population Served: 35,000 persons

Receiving Stream: Two Mile Creek, tributary to upper Niagara River, East Channel

## Town of Tonawanda - Sewer District No. 3 Plant, New York

Operated by: Town of Tonawanda

Communities Served: Town of Tonawanda

Treatment: Sedimentation (Imhoff tank), trickling filters, covered sludge drying beds. No chlorination.

Design Flow: 0.50 M.G.D. (U.S.)

Present Flow: 0.75 M.G.D. (U.S.)

Design Population: 5,000 persons

Population Served: 1,000 persons

Receiving Stream: Ellicott Creek, tributary to upper Niagara River, East Channel

### Niagara Falls Plant, New York

Operated by: City of Niagara Falls

Communities Served: City of Niagara Falls and surrounding area in Towns of Wheatfield and Niagara

Treatment: Grit chambers, fine screens, chlorination of effluent during summer, sludge dewatering and incineration

Design Flow: 40 M.G.D. (U. S.) with filter medium; 90 M.G.D. (U. S.) without

Present Flow: 75 M.G.D. (U. S.) average

Population Served: 105,450 persons (Exclusive of industrial wastes)

Receiving Stream: Lower Niagara River

### Youngstown Plant, New York

Operated by: Village of Youngstown

Communities Served: Village of Youngstown

Treatment: Bar screen, sedimentation (Imhoff tank), sludge drying beds, chlorination

Design Flow: 0.548 M.G.D. (U. S.)

Present Flow: Estimated 0.25 M.G.D. (U.S.)

Design Population: 2,500 persons

Population Served: 1,500 persons

Receiving Stream: Lake Ontario

## Crystal Beach Plant, Ontario

Operated by: Crystal Beach Village

Communities Served: Crystal Beach Village

Treatment: Activated sludge, postchlorination, sludge burial

Design Flow: 0.30 M.G.D. (Imp.)

Present Flow: 0.15 M.G.D. (Imp.) in winter;
0.6 M.G.D. (Imp.) in summer

Design Population: 3,000 persons

Population Served: 1,300 (8,000 in summer)

Receiving Stream: Lake Erie

## Fort Erie Plant, Ontario

Operated by: Town of Fort Erie

Communities Served: Town of Fort Erie

Treatment: Septic Tank

Design Flow: 0.10 M.G.D. (Imp.)

Present Flow: 1.2 M.G.D. (Imp.)

Design Population: 2,000 persons

Population Served: 7,500 persons

Receiving Stream: Upper Niagara River

## Chippawa Plant, Ontario

Operated by: Village of Chippawa

Communities Served: Village of Chippawa

Treatment: Two Septic Tanks

Design Flow: No data available

Present Flow: 0.4 M.G.D. (Imp.)

Population Served: 1,600 persons

Receiving Stream: Welland River, tributary to lower Niagara River
via H.E.P.C. power canal

## Stamford Plant, Ontario

| | |
|---|---|
| Operated by: | Township of Stamford |
| Communities Served: | Township of Stamford |
| Treatment: | Three Septic Tanks |
| Design Flow: | No data available |
| Present Flow: | 1.1 M.G.D. (Imp.) |
| Population Served: | 8,000 persons |
| Receiving Stream: | H. E. P. C. power canal, tributary to lower Niagara River |

The effectiveness of treatment by several of these plants is not disclosed by the facilities provided. On the United States side, both the Lackawanna and the Blasdell plants are considerably overloaded, and as they discharge into small creeks, local authorities have instigated action to ameliorate the pollution problems. Thus, efforts have been made to enlarge the Lackawanna plant and plans have been prepared for a new plant at Blasdell. On the Canadian side, the Crystal Beach treatment works is considerably overloaded for secondary treatment during the summer resort period. Also, the septic tank treatment at Fort Erie, Chippawa, and Stamford Township is inadequate.

Of even greater significance than the overloaded plants are those municipalities discharging untreated sewage into the boundary waters. The cities of North Tonawanda, New York, and Niagara Falls, Ontario, both discharging directly to the Niagara River, are the principal offenders. Also of importance is the City of Welland which discharges its untreated sewage to the lower river by way of the Hydro Electric Power Commission's power canal, and Stamford Township, discharging about half its raw sewage to the lower Niagara River.

Abatement of pollution from domestic sewage will require collection and treatment for the entire area.

Combined Sewer Overflows

With combined sewer systems, large volumes of sanitary sewage and process wastes reach the boundary waters during periods of excessive storm run-off. In these combined systems, the sewers are designed to carry the dry-weather flow, together with some multiple of this flow as storm water. Usually this multiple does not exceed two or three. Consequently, during periods of storm run-off exceeding this amount, the excess mixture of storm and sanitary flow, instead of going to the sewage treatment plant, discharges directly to the boundary waters or their tributaries through combined sewer overflows.

Most of the sewers in this area are of combined type, hence storm water overflows are numerous. The major ones are located along the Buffalo River and the Niagara River in the cities of Buffalo, Tonawanda, and Niagara Falls, New York. In Buffalo there are 34 overflows discharging to the Buffalo River, 12 to the harbor area, and 4 to the upper Niagara River. The City of Tonawanda has three overflows that discharge to the upper Niagara River and Ellicott Creek. Niagara Falls, New York, maintains eight overflows, all discharging to the lower Niagara River. Of the Canadian communities, none has combined storm water overflows.

The above combined sewer overflows do not receive any treatment, and consequently, full benefit from existing interceptors and treatment facilities is not realized. Intermittent pollution occurs under those conditions.

The City of Lackawanna, however, chlorinates excess storm water before it overflows to Smokes Creek, a tributary of Lake Erie.

### Refuse Disposal

An added factor in the pollution problem of these boundary waters is the careless and thoughtless disposal of garbage and other refuse. Such wastes add pollution, create an unsightly appearance, and present hazards to small watercraft. The wastes originate from ships, shore residences and from wilful dumping by careless persons.

While much refuse was formerly dumped by the municipalities into the Niagara River, there is little evidence, with the exception of Niagara Falls, New York, that pollution from such sources has taken place recently. Garbage is usually disposed of by incineration or used as fertilizer or hog feed. Many of the small communities have contracts with private concerns who bury the garbage. Ashes and rubbish are either incinerated or used as land fill. Niagara Falls, New York, normally incinerates refuse, with the ashes being used as fill. However, in 1949 when the breakdown of an incinerator unit made emergency disposal necessary, garbage was dumped into the river for several weeks until discovered by a representative of the New York State Department of Health. Conferences with the city officials resulted in its immediate discontinuance.

The practice of dumping refuse in locations where it can drain into or directly enter these waters is highly objectionable, and all means should be taken to prevent it.

## INDUSTRIAL WASTES

Industrial wastes are the chief sources of chemical pollution, as distinguished from bacterial pollution in sewage, and they are much less significant from the standpoint of disease. The chief objection to many of these wastes is that they contain taste and odor producing compounds, chlorine-consuming compounds, and toxic substances. Other polluting effects result from the discharge of oils, solids, acids, oxygen-consuming wastes, and other materials which impart an unsightly appearance, and otherwise injuriously affect the usage of the waters.

Pollution by industrial wastes occurs mainly on the United States side at the east end of Lake Erie, the Buffalo River, and along the east side of the upper Niagara River. There is no industrial pollution directly into the lower Niagara River except through the Niagara Falls, New York, diversion sewer system and through the power canal of the Ontario Hydro Electric Power Commission.

The 34 major industries which were studied are listed in table 14 by types of production.

Table 14 — NUMBER AND TYPES OF INDUSTRIES STUDIED

| Type of Industry | Number of Plants | | |
|---|---|---|---|
| | United States | Canada | Total |
| Automotive | 1 | 0 | 1 |
| Chemical | 9 | 2 | 11 |
| Coke and By-products | 2 | 0 | 2 |
| Gas Manufacturing | 2 | 0 | 2 |
| Oil Refinery | 2 | 0 | 2 |
| Paper and Fibre Products | 5 | 0 | 5 |
| Rubber | 1 | 0 | 1 |
| * Steel | 4 | 0 | 4 |
| Electrothermal | 2 | 2 | 4 |
| Synthetic Fibre | 1 | 0 | 1 |
| Miscellaneous | 1 | 0 | 1 |
| TOTAL | 30 | 4 | 34 |

* One of the steel plants operates a coke plant not included above.

Information on industrial wastes produced daily in the Lake Erie-Lake Ontario Section is contained in table 15. The flows shown in the table include cooling and condenser waters as well as process wastes. Also included in this table are the industrial waste discharges to the City of Niagara Falls, New York, sewage treatment works. This is primarily a screening plant and since it was not designed to remove industrial waste pollutants, such wastes tend to pass through without modification.

Where industrial wastes are discharged into the tributary streams, the total amounts of the polluting constituents may not reach the boundary waters since natural purification tends to reduce or alter such substances as phenols, cyanides, and ammonium and sulfur compounds.

Table 15

## SUMMARY OF INDUSTRIAL WASTES DISCHARGED DAILY

| Area | Total Flow Million Gallons (U. S.) | Total Flow Million Gallons (Imp.) | Phenol (Pounds) | Cyanides as $CN^-$ (Pounds) | Ammonium Compounds as $NH_3$ (Pounds) | Oil & Ether-Extractable Materials U. S. Gallons | Oil & Ether-Extractable Materials Imp. Gallons | Suspended Solids (Pounds) |
|---|---|---|---|---|---|---|---|---|
| **United States Side** | | | | | | | | |
| Lake Erie | 155 | 129 | 120 | 0 | 5,530 | 990 | 825 | 180,900 |
| Niagara River | 305 | 254 | 6,250 | 1,720 | 655 | 900 | 750 | 567,200 |
| Lake Ontario | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TOTAL | 460 | 383 | 6,370 | 1,720 | 6,185 | 1,890 | 1,575 | 748,100 |
| **Canadian Side** | | | | | | | | |
| Lake Erie | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Niagara River | 36 | 30 | 0 | 35 | 4,380 | 0 | 0 | 9,030 |
| Lake Ontario | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TOTAL | 36 | 30 | 0 | 35 | 4,380 | 0 | 0 | 9,030 |
| **Combined - United States and Canada** | | | | | | | | |
| Lake Erie | 155 | 129 | 120 | 0 | 5,530 | 990 | 825 | 180,900 |
| Niagara River | 341 | 284 | 6,250 | 1,755 | 5,035 | 900 | 750 | 576,230 |
| Lake Ontario | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TOTAL | 496 | 413 | 6,370 | 1,755 | 10,565 | 1,890 | 1,575 | 757,130 |

## Origin of Wastes

The significant waste constituents shown in table 15 result from a variety of industrial processes. Each plant may produce one or more of these substances. They are discharged at both uniform rates and in batches of varying concentrations, the latter constituting a slug or a spill.

### Phenolic Compounds

Phenol and phenolic equivalents originate from by-product coke and gas plant operations, crude oil refining, blast furnaces, and from plants in which phenol is used as a raw material.

Phenol compounds were found only on the United States side, in the wastes from

Semet-Solvay Division, Allied Chemical & Dye Corporation
Durez Plastics & Chemicals, Inc.
Donner-Hanna Coke Corporation
National Aniline Division, Allied Chemical & Dye Corporation
Spaulding Fibre Company, Inc.
Republic Steel Corporation
Bethlehem Steel Company
Socony-Vacuum Oil Company, Inc.
Wickwire Spencer Steel Division, Colorado Fuel & Iron Corporation
Carborundum Company
Hooker Electrochemical Company

### Cyanides

Cyanides originate chiefly from by-product coke ovens, electroplating processes, tar processing plants, blast furnaces, oil refineries, and some chemical manufacturing plants. Cyanides were found on the United States side in the wastes from

Donner-Hanna Coke Corporation
E. I. duPont de Nemours & Co., Inc., Electrochemicals Department
National Aniline Division, Allied Chemical & Dye Corporation
Semet-Solvay Division, Allied Chemical & Dye Corporation
Republic Steel Corporation
Wickwire Spencer Steel Division, Colorado Fuel & Iron Corporation
Socony-Vacuum Oil Company, Inc.

and on the Canadian side from

North American Cyanamid Limited, Welland Works

Ammonium Compounds

Ammonium compounds are found in the wastes from by-product coke ovens, chemical plants, gas plants, and tar processing plants. They were present, on the United States side, in the wastes from

Bethlehem Steel Corporation
Durez Plastics & Chemicals, Inc.
Semet-Solvay Division, Allied Chemical & Dye Corporation
Donner-Hanna Coke Corporation

and on the Canadian side from

North American Cyanamid Limited, Welland Works

Oils and other Ether-extractable Materials

Oils and other ether-extractable materials were found on the United States side only, in the wastes from

Bethlehem Steel Company
Chevrolet-Tonawanda, Division of General Motors Corporation
Socony-Vacuum Oil Company, Inc.

Wickwire Spencer Steel Division, Colorado Fuel & Iron Corporation

Semet-Solvay Division, Allied Chemical & Dye Corporation

Frontier Oil Refining Corporation

Donner-Hanna Coke Corporation

Suspended Solids

Suspended solids were found, on the United States side, to be contributed chiefly from

Bethlehem Steel Company

International Paper Company, Niagara Falls Plant

Wickwire Spencer Steel Division, Colorado Fuel & Iron Corporation

E. I. duPont de Nemours & Co., Inc., Electrochemicals Department

Electro Metallurgical Division, Union Carbide & Carbon Corporation

National Aniline Division, Allied Chemical & Dye Corporation

International Paper Company, Tonawanda Plant

Republic Steel Corporation

Carborundum Company

Kimberly-Clark Corporation

E. I. duPont de Nemours & Co., Inc., Rayon Division

Semet-Solvay Division, Allied Chemical & Dye Corporation

Tonawanda Boxboards Division, Robert Gair Company, Inc.

Mathieson Chemical Corporation

Spaulding Fibre Company, Inc.

Donner-Hanna Coke Corporation

Durez Plastics & Chemicals, Inc.

Hooker Electrochemical Company

Oldbury Electro-Chemical Company

Chevrolet-Tonawanda, Division of General Motors Corporation and on the Canadian side from

North American Cyanamid Limited, Welland Works

North American Cyanamid Limited, Niagara Falls Plant

Norton Company

Canadian Carborundum Company

Biochemical Oxygen Demand

Biochemical oxygen demand is due to organic materials. Substantial amounts were found, on the United States side, in the wastes from

National Aniline Division, Allied Chemical & Dye Corporation

International Paper Company, Niagara Falls Plant

International Paper Company, Tonawanda Plant

Donner-Hanna Coke Corporation

Wickwire Spencer Steel Division, Colorado Fuel & Iron Corporation

E. I. du Pont de Nemours & Co., Inc., Rayon Division

Durez Plastics & Chemicals, Inc.

Semet-Solvay Division, Allied Chemical & Dye Corporation

Hooker Electrochemical Company

E. I. du Pont de Nemours & Co., Inc., Electrochemicals Department

Bethlehem Steel Company

The biochemical oxygen demand (B.O.D.) test of a waste is a measurement of the strength or concentration of its oxidizable organic matter. The "Population Equivalent" value provides a basis on which industrial wastes may be compared with domestic sewage insofar as oxygen-consuming qualities are concerned. The coefficient of 0.17 pound of 5-day, 20° C., B.O.D. per capita per day is used for converting the B.O.D. value to a population equivalent figure. The B.O.D. of the industrial wastes and their corresponding population equivalents are listed in table 16. These figures do not necessarily imply an equivalent bacterial pollution load.

Table 16 — POPULATION EQUIVALENT OF INDUSTRIAL WASTE DISCHARGES

| Area | B.O.D. - Pounds Daily | | | Population Equivalent - Persons | | |
|---|---|---|---|---|---|---|
| | U. S. | Can. | Total | U. S. | Can. | Total |
| Lake Erie | * | 0 | - | * | 0 | - |
| Niagara River | 96,000 | * | 96,000+ | 565,100 | * | 565,100+ |
| Lake Ontario | 0 | 0 | 0 | 0 | 0 | 0 |
| TOTAL | 96,000+ | 0 | 96,000+ | 565,100+ | 0 | 565,100+ |

* Amount undetermined.

Miscellaneous

Miscellaneous polluting substances, as indicated, were found on the United States side in wastes from

General Chemical Division, Allied Chemical & Dye Corporation - Acid

Bethlehem Steel Company - Acid, iron, sanitary sewage

National Aniline Division, Allied Chemical & Dye Corporation - Acid, iron

Niacet Chemicals Division, United States Vanadium Corporation, Unit of Union Carbide & Carbon Corp. - Acid, zinc

Republic Steel Corporation - Iron

Wickwire Spencer Steel Division, Colorado Fuel & Iron Corporation - Iron

E. I. du Pont de Nemours & Co., Inc., Rayon Division - Acid, zinc

## WASTES FROM DREDGING

The deposition of solids in the Buffalo River, the Buffalo River entrance channel, Buffalo Outer Harbor, and the upper Niagara River is caused by soil erosion on the watershed and from the large amounts of domestic and industrial wastes discharged into these waters. The U. S. Army, Corps of Engineers, has an annual program of maintenance dredging for navigation purposes. The annual expenditure for this work now amounts to about $200,000, of which $150,000 is spent in maintaining the Buffalo River. Deepening a part of the Buffalo River during the winter of 1949-50 was undertaken by the Corps of Engineers with an added expenditure of $550,000.

During the past five years, a total of about two million cubic yards of dredged material has been taken from the Buffalo River, Outer Harbor, and the upper Niagara River. From the Buffalo River alone, about 850,000 cubic yards of material has been removed. It consisted of about 80% mud, 15% sand, and the rest small amounts of rock, gravel, and clay. About 550,000 cubic yards of silt, mud, and sand were dredged from the entrance channel to the Buffalo River and the Outer Harbor. This material was composed of about 50% silt, 25% mud, and the rest varying proportions of sand, clay, rock and gravel.

Dredging from the Black Rock Canal and the upper Niagara River has removed a total of 710,000 cubic yards of material. Of this amount, 408,500 cubic yards were removed by Government labor, and consisted of about 45% sand, 25% silt, 20% mud, and 10% gravel. About 300,600 cubic yards of earth and rock have also been removed by Government contract since 1945.

The dredged materials from the Buffalo River, the Buffalo River entrance, the Outer Harbor, and Black Rock Canal are deposited in an area approximately 1.4 miles long and 0.7 mile wide in Lake Erie adjacent to the Bethlehem Steel Company's plant near the mouth of Smokes Creek. The material dredged from the Niagara River downstream from Tonawanda Island is dumped in an area approximately 900 feet square in the Niagara River between the northerly shore of Buckhorn Island on Grand Island and the Federal-maintained channel in the east branch of the Niagara River. No other disposal areas are established or contemplated at the present time.

The raw water quality at the Western New York Water Company has deteriorated appreciably within recent years, particularly in regard to taste and odor. This is due in part to the disposal of dredged material in the Lake Erie dumping grounds near the company's water intake. The water intake line, extending 4,425 feet from shore, approximately parallels the southerly limit of the area, the intake crib being 750 feet distant. The increasing problem of producing a satisfactory water prompted a conference in June 1947 for consideration of relocating this disposal area. The Corps of Engineers indicated that since 1945 they had segregated the dredged material, dumping the rock which usually comes from the Black Rock channel in that part of the designated area closest to the water intake, and the sludge and fine material from the Buffalo River basin and harbor in the area farthest from the intake. Buoys were placed to show the limits of the areas where these materials were to be dumped.

Relocation of the dump area would necessitate transporting the dredged material a greater distance with the resulting curtailment of dredging operations because of limited funds provided for this purpose. The capacity of the dumping grounds is nearly reached and dumping is more difficult each year. The solution of this problem will be the relocation of the dumping area or extension of the water intake of the Western New York Water Company.

## WASTES FROM NAVIGATION

Data obtained from the U. S. Army Corps of Engineers and the individual vessel companies were used to ascertain the extent of vessel passages and the freight and passenger traffic in the eastern end of Lake Erie, the Niagara River, and Lake Ontario.

Sanitary wastes from vessels are confined mostly to navigation channels where discharges occur intermittently, and in harbors when the vessels are in port. While there is some interest in retention tanks among vessel operators, there is no present Federal regulation requiring their installation. Although no freight vessels are so equipped, all of the passenger vessels operating into Buffalo have retention tanks. Sewage stored in the tanks is usually emptied shortly after departure from the harbor area. A mass of sewage is thereby introduced in a limited area on the navigation route, and other vessels following shortly thereafter may draw this contaminated water for domestic purposes.

Pollution contributed by vessels navigating these waters is considered to be significant. One of the passenger ships which plies Lake Erie has a capacity of 2,500 persons and a crew of 225 members. The volume of waste from such large vessels is important. The U. S. Public Health Service estimates the quantity of water used per person to be 30 gallons per day, all of which is discharged as waste in one form or another.

Garbage and rubbish are stored in containers aboard vessels and either dumped overboard in open bodies of water or removed at shore points. The overboard dumping practice pollutes the water and causes nuisances along the shores.

Bilge and ballast water may also be discharged overboard from vessels. Bilge water includes seepage through the hull, and leakage from water lines, pumps and machinery, and contains some lubricating oils and greases. The quantity of this waste is highly variable and it is difficult to estimate the amount of oils discharged with it. Ballast water is used to stabilize the vessel under various operating conditions. On tankers particularly, water is pumped into the empty oil tanks for ballast and discharged overboard before cargo is received. Thus, some oil may be pumped overboard with the ballast water unless oil separation is practiced. Lake water is many times pumped into or discharged from ballast tanks while the vessel is enroute, and this practice may transfer contaminated water taken aboard at one location to a relatively clean area.

Jurisdiction regarding the discharge of pollutants from vessels into these waters is embodied in the River and Harbor Act and the Interstate Quarantine Regulations of the United States Government. The former act prohibits the deposit of any refuse matter, including sewage and oil wastes, from vessels into navigable waters of the United States or into any water which may convey the same into navigable waters. This restriction is more specifically outlined in the Interstate Quarantine Regulations. These regulations state that vessels operating on fresh water lakes or rivers shall not discharge sewage, ballast or bilge water within such areas adjacent to domestic water intakes as are designated by the Surgeon General, Public Health Service. No such areas have been delimited in accordance with these regulations in the Lake Erie-Lake Ontario Section. Local regulations in many areas prohibit the discharge of any wastes from a vessel in the vicinity of water supply intakes and bathing beaches. Such restricted areas should be adequately designated and vessel operators should exert care to insure that these requirements are strictly observed.

# CHAPTER VIII

# POLLUTION EFFECTS ON BOUNDARY WATER QUALITY

"And being once amisse growes daily wourse
and wourse."

– The Fairie Queene

The effects of pollution have been measured by bacteriological, chemical and physical examinations. The analytical tests were supplemented by data on municipal water supplies, sewage effluents, and industrial wastes. This information has shown the extent and intensity of pollution both in the boundary waters and tributaries, the changes which take place between the sources of pollution, and the suitability of these waters for the various uses discussed previously.

A total of 4,401 surface water samples was taken during the investigation for bacteriological examinations, 98 for plankton determinations, and 3,279 for chemical tests. The analyses were made in the field laboratories located at St. Catharines, Ontario, and Fort Niagara and Niagara Falls, New York.

## EXPLANATION OF LABORATORY TESTS

The analytical determinations used in the survey are listed below. An explanation of each is given as an aid in interpreting the significance of the tests.

### Bacteriological Examinations

Bacteriological examinations were limited to the confirmed test for the coliform group of bacteria. These bacteria are normal inhabitants of the intestines of man and other warm-blooded animals, and are discharged in large numbers in human feces. This test is the specific means of approximating the density of organisms of the coliform group which are present in large numbers in sewage and are, in general, relatively few in number in wastes from industries. The results are reported as "most probable number" (M.P.N.) per 100 milliliter. This is now commonly known as the M.P.N. Index.

The water in the main body of Lake Erie, not subject to direct contamination, is relatively free of coliform bacteria, having less than 10 M.P.N. per 100 ml. Raw domestic sewage may contain many million coliform bacteria per 100 ml.

### Plankton Determinations

Microscopic examination for free-floating micro-organisms known as plankton is useful in explaining causes of taste, odor, and turbidity of waters. In Lake Erie certain plankton are a potential taste and odor hazard to all the water supplies downstream on the Niagara River. These organisms may disintegrate in water, and the volatile oils from their cells may be carried downstream to water supply intakes. Identification of these offending organisms serves as a basis for instituting corrective treatment.

### Chlorides

All fresh waters contain chlorides, the normal amount varying in different regions. An increase above normal is an indication of contamination from sewage or industrial wastes. The normal chloride content of Lake Erie water is about 20 parts per million (p.p.m.). Chlorides increase the soap consuming properties of water and adversely affect boiler feed water. They are not removed by the usual water purification processes.

## Phenolic Compounds

Phenolic substances in water react with the chlorine, normally applied at water treatment plants, to produce intensely aromatic compounds. These compounds, even when highly diluted, may give a taste and odor to the water which is variously described as medicinal, chemical, or iodoform. Phenolic compounds in low concentrations taint fish and in higher concentrations, are toxic to fish. Normally, water contains no phenolic compounds. In this study phenols and phenolic equivalents were measured by the Gibbs Method with modifications.

## Ammonium Compounds

Ammonium compounds include free ammonia and ammonium salts, but they do not include albuminoid ammonia or organic nitrogen. The ammonium ion tends to combine with chlorine to form chloramines in public water supplies and thereby increases the chlorine demand. Ammonium compounds are also toxic to fish. Lake Erie samples showed only trace quantities. Any substantial increase may be attributed to sewage and industrial wastes of an organic type.

## Chlorine Demand

The chlorine demand test is an indicator of the amount of organic matter present in water. It increases with the addition of sewage and other organic pollutants. The difficulty and cost of the chlorination of water are increased where there is a high chlorine demand. Erratic chlorine demand of a water supply source constitutes a public health hazard.

## Temperature

The temperature of water influences the solubility of oxygen and the rate of oxidation and self-purification.

## Dissolved Oxygen

The amount of dissolved oxygen contained in unpolluted water fluctuates with the temperature. A deficiency of oxygen is replaced by solution of oxygen from the atmosphere. There is a saturation value for each temperature. At 10° Centigrade (50° Fahrenheit) this value is 11.33 p.p.m. of dissolved oxygen. Values below saturation indicate the presence of polluting organic substances which are absorbing oxygen from the water. The extent of this deficiency is one index of the degree of organic pollution. Substantial reduction in dissolved oxygen causes odor nuisances and suffocation of fish.

## Biochemical Oxygen Demand (B.O.D.)

The biochemical oxygen demand test indicates the amount of oxygen required for stabilization of the decomposable organic matter. The time and temperature used for this test are 5 days and 20° C., respectively. The B.O.D. of Lake Erie water, unaffected by pollution, approaches zero, while for raw sewage it varies from about 100 to 300 p.p.m.

## Turbidity

Turbidity is a measure of the fine suspended solids in water such as silt and finely divided organic matter.

## Solids

The analyses for solids include tests for total and suspended solids as well as their volatile constituents. The former measures both the solids in solution and in suspension. The total volatile solids indicate the amount of organic matter present in the water. Both sewage and industrial wastes have significant amounts of solids. Domestic sewage contains about 0.2 pound of suspended solids per capita per day. The solids content of an industrial waste varies with the type of industry.

The effects of suspended solids in water are reflected in the difficulties associated with water purification, deposition in streams, interference with navigation, and injury to the habitat of fish.

### Hydrogen Ion Concentration

The hydrogen ion concentration (pH value) of a water indicates its relative acidity or alkalinity. It is a measure of intensity rather than of quantity. A neutral water has a pH of 7.0. Higher values are in the alkaline range, and the lower in the acid range. The pH of Lake Erie water averages about 7.8. Any appreciable departure from this value indicates the addition of acid or alkaline wastes.

### Alkalinity

Alkalinity represents the concentration of carbonates, bicarbonates, hydroxides, and occasionally borates, silicates, and phosphates. Industrial waste discharges high in alkalinity generally affect the hardness of the water. Hardness is an economic factor in the use of a water supply either for domestic or industrial purposes.

### Oils and other Ether-Extractable Materials

Oils and other ether-extractable materials include such substances as greases and tars. The presence of these pollutants renders water difficult and sometimes impractical to treat either for industrial or domestic use. Oils make beaches unsightly and waters unfit for bathing. They coat watercraft and are a hazard to waterfowl.

### Tastes and Odors

Tastes and odors in water may be associated with the presence of polluting or otherwise objectionable substances such as decomposing organic matter, plankton organisms, and chemical compounds including free chlorine, hydrogen sulfide, and phenols. The determination of the quality and intensity indicates the degree of consumer acceptance of a water supply. These determinations aid in the search for the substances responsible for tastes and odors that may be due to waste discharges or to organic material naturally present in the stream. Odor results are expressed in terms of threshold odor numbers, these values increasing with the amount of odor-free diluting water required to cause disappearance of the odor. Tastes are determined in like manner, and are expressed as the dilution required. Both taste and odor are described by quality or characteristic as well as intensity.

### Cyanides

Cyanides are probably the most toxic substances in industrial wastes. Concentrations over 0.05 p.p.m. are not acceptable in a drinking water supply. Low concentrations of between 0.1 and 0.3 p.p.m. are fatal to fish. Cyanides are not natural components of surface waters.

## ANALYTICAL RESULTS OF THE 1913 INVESTIGATION

Investigation of these waters in 1948-49 revealed that the nature, character, and extent of the pollution found at this time differed materially from the findings of the 1913 survey. In the earlier study, pollution originated almost entirely from sewage.

The industrial development in the Niagara Frontier area at that time was still in its infancy. Power resources at the Falls had not yet attracted the many chemical and allied industries which exist today. Low-cost water transportation has since made the Frontier a manufacturing center and distribution point for a widespread marketing area. Consequently, many of the industries existing today were either not yet established or were operating on a much smaller scale.

The findings in the earlier investigation were based entirely on B. coli examinations. The results were expressed in terms of the "Phelps Index" as the approximate number of B. coli in 100 ml. of the sample when calculated from the results of single tube dilution tests. The "Coliform group" as recorded in this report may be considered to correspond to the "B. coli group" as used formerly. Laboratory procedures have been refined in the intervening years in an effort to obtain greater precision in the estimation of the number of coliform organisms. While comparisons in results of the two investigations can be approximate only, it may be assumed that the M.P.N. figures used in this investigation are 2.4 times greater than numbers which would be given by the "Phelps Index."

In the "Final Report of the International Joint Commission" conditions in the Lake Erie-Lake Ontario Section in 1913 were summarized as follows:

> "The purity of the main body of the lake (Erie) was amply established by examination of its water at several widely separated stations."
>
> "This investigation showed that above Niagara Falls the bulk of the pollution in the river, and due to the discharge of sewage therein, is confined to the marginal waters of the country in which it originates and that the sewage of Buffalo is polluting to a serious extent the available water supplies of the two Tonawandas and the city of Niagara Falls, New York."
>
> "The effect of the pollution of the lower Niagara is to render the river totally unfit for domestic uses unless purified. All of the lower municipalities have been forced to install and operate water purification plants, and the result of their operation shows only too clearly that the use of the water is accompanied by no proper margin of safety."
>
> "The investigation revealed the fact that the waters of Lake Ontario are comparatively free of B. coli, with the exception of the 18 mile radius from the mouth of the Niagara River."

## ANALYTICAL RESULTS OF THE 1948-1949 INVESTIGATION

Tables 17 to 20, inclusive, present a summary of the analytical results of the bacteriological, chemical, and physical analyses of samples taken during the 1948-1949 survey. Sampling covered the area extending from the eastern end of Lake Erie, through the Niagara River, to a portion of Lake Ontario at the outlet of the Niagara River. The tables give the average values for the chemical and physical tests and the median for bacteriological tests, the maximum and minimum results, and the number of samples analyzed.

A review of the analytical data indicates that the most significant results are the coliform and phenol determinations. Other chemical and physical examinations were conducted routinely but were found not to be sufficiently indicative to denote the trends or paths of pollution. The chloride content of about 20 p.p.m. in Lake Erie was virtually unchanged in this section of the boundary waters. Similarly, the alkalinity of 95 p.p.m. and the pH value of 7.8 found in Lake Erie did not change appreciably. Average turbidity results ranged from 0 to about 5 p.p.m. in Lake Erie and Lake Ontario and as high as 20 p.p.m. in the river, but this difference is not significant. The average B.O.D. values were low, with results ranging between 0 and 2.6 p.p.m. along this stretch of boundary waters. The dissolved oxygen results showed low reduction from saturation, indicating the absence of any oxygen problem. The content of ammonium compounds was uniformly low in the Niagara River but a few high values were noted in Lake Ontario. Primary emphasis is placed on the coliform and phenol determinations in the discussion of the analytical results which follows.

## Lake Erie

The summary of analytical results for samples taken in Buffalo Outer Harbor and the eastern end of Lake Erie is presented in table 17. The coliform results are plotted in figure 3 and the phenol data in figure 4. In Buffalo Outer Harbor, median coliform M.P.N. values ranged from 11 to 4,600 per 100 ml., with a maximum value of 110,000. Phenol determinations at the southern end of the harbor showed average results as high as 49 parts per billion (p.p.b.) and a maximum of 200 p.p.b. Biochemical oxygen demand results were relatively low, the highest average value being 1.5 p.p.m. Average total iron results on a range at the south end of the harbor varied from 1.0 to 2.8 p.p.m. with a maximum of 3.5 p.p.m.

The water along the United States shore, south of the outer harbor, shows pollution from both sewage and industrial wastes. Coliform median M.P.N. values ranged from 430 to 240,000 per 100 ml. with a maximum value greater than 11,000,000 at one shore sampling point. Offshore 2,500 feet, the results show a substantial reduction in coliforms with the medians varying from 43 to 390. Phenol results along shore were also high; a maximum of 220 p.p.b. was noted. A similar reduction in values was found offshore.

The main body of water at the eastern end of Lake Erie is of good sanitary quality and is relatively free from domestic and industrial pollution. Median coliform M.P.N. values were less than 10 per 100 ml. Phenol concentrations averaged about 1 p.p.b. with maximums up to 6 p.p.b., except for one sample taken in the vicinity of Seneca Shoal which contained 140 p.p.b. and for which no reason is apparent. Turbidity averages ranged from 1 to 4 p.p.m. with a maximum value only slightly higher.

The water along the Canadian shore was also of good sanitary quality, with median coliform M.P.N. values ranging from less than 3 to 16 per 100 ml. Phenol results averaged about 1 p.p.b. except along the range LC offshore from Crystal Beach, where the averages were considerably higher. A maximum as high as 400 p.p.b. was noted on this range and again there is no satisfactory explanation.

## Table 17 - SUMMARY OF AVERAGE ANALYTICAL RESULTS - LAKE ERIE

| Sampling Range and Location | Station (Feet) | | Coliforms M.P.N. per 100ml. | Chlorides ppm | Phenols ppb | Ammonia as $N_2$ ppm | Temp. °C | D.O. ppm | B.O.D. 5 Day ppm | Turbidity ppm | pH | Alkalinity ppm | Total Iron ppm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BA A range in Buffalo Harbor from the United States Coast Guard slip to Anchorage Light on the breakwater | 0 | | UNITED STATES SHORE | | | | | | | | | | |
| | 100 | Average | (Median)<br>430 | 21 | 2 | 0.04 | 10 | 10.9 | 0.8 | 11 | 8.0 | 88 | |
| | | Maximum | 4,600 | 25 | 10 | 0.20 | 23 | 12.9 | 1.3 | 24 | 8.4 | 98 | |
| | | Minimum | 36 | 17 | 0 | 0 | 2 | 8.2 | 0.4 | 2 | 7.4 | 59 | |
| | | No. of Samples | 24 | 16 | 24 | 18 | 20 | 17 | 14 | 20 | 20 | 15 | |
| | | | | | | | | | | | | | |
| | 700 | Average | (Median)<br>150 | 21 | 2 | 0.02 | 12 | 10.3 | 1.0 | 9 | 8.0 | 91 | |
| | | Maximum | 2,400 | 25 | 14 | 0.14 | 25 | 13.1 | 3.0 | 22 | 8.4 | 96 | |
| | | Minimum | 23 | 18 | 0 | 0 | 2 | 6.0 | 0.4 | 1 | 7.6 | 85 | |
| | | No. of Samples | 26 | 23 | 26 | 23 | 27 | 24 | 21 | 27 | 26 | 22 | |
| | | | | | | | | | | | | | |
| | 1500 | Average | (Median)<br>120 | 21 | 1 | 0.01 | 10 | 11.0 | 0.8 | 11 | 8.0 | 92 | |
| | | Maximum | 2,400 | 25 | 8 | 0.08 | 22 | 13.1 | 1.4 | 22 | 8.4 | 98 | |
| | | Minimum | < 3.6 | 18 | 0 | 0 | 2 | 8.1 | 0.3 | 1 | 7.5 | 87 | |
| | | No. of Samples | 24 | 16 | 24 | 18 | 20 | 17 | 15 | 20 | 20 | 15 | |
| | | | | | | | | | | | | | |
| FH A range in Buffalo Harbor from the north end of the Ford Company dock to the breakwater | 0 | | UNITED STATES SHORE | | | | | | | | | | |
| | 100 | Average | (Median)<br>230 | 21 | 5 | 0.04 | 12 | 10.6 | 0.8 | 10 | 8.1 | 93 | |
| | | Maximum | 1,100 | 26 | 25 | 0.24 | 23 | 13.0 | 1.3 | 23 | 8.5 | 97 | |
| | | Minimum | 43 | 18 | 0 | 0 | 2 | 8.4 | 0.6 | 2 | 7.7 | 85 | |
| | | No. of Samples | 16 | 11 | 16 | 12 | 14 | 12 | 9 | 14 | 14 | 10 | |
| | | | | | | | | | | | | | |
| | 700 | Average | (Median)<br>150 | 21 | 4 | 0.04 | 14 | 10.1 | 1.1 | 8 | 8.1 | 92 | |
| | | Maximum | 2,400 | 26 | 30 | 0.20 | 24 | 13.2 | 5.5 | 20 | 8.6 | 96 | |
| | | Minimum | 43 | 17 | 0 | 0 | 2 | 8.2 | 0.5 | 1 | 7.5 | 86 | |
| | | No. of Samples | 18 | 16 | 18 | 15 | 19 | 17 | 15 | 19 | 18 | 15 | |
| | | | | | | | | | | | | | |
| | 1500 | Average | (Median)<br>120 | 21 | 4 | 0.04 | 12 | 10.5 | 0.8 | 12 | 8.1 | 93 | |
| | | Maximum | 930 | 24 | 25 | 0.16 | 23 | 13.2 | 1.7 | 38 | 8.6 | 96 | |
| | | Minimum | < 3.0 | 18 | 0 | 0 | 2 | 8.3 | 0.3 | 1 | 7.6 | 87 | |
| | | No. of Samples | 16 | 11 | 16 | 12 | 14 | 11 | 8 | 14 | 14 | 10 | |
| | | | | | | | | | | | | | |
| UL A range in Buffalo Harbor from the mouth of Union Canal thru south entrance to a point 300' west of South Pier Light | 0 | | UNITED STATES SHORE | | | | | | | | | | |
| | 100 | Average | (Median)<br>4,600 | 23 | 27 | 0.57 | 18 | 8.2 | 1.5 | 26 | 8.0 | 101 | 2.8 |
| | | Maximum | 110,000 | 28 | 90 | 1.5 | 30 | 9.6 | 6.7 | 107 | 8.5 | 130 | 3.5 |
| | | Minimum | 93 | 18 | 0 | 0.12 | 2 | 6.5 | 0.3 | 2 | 7.5 | 94 | 2.2 |
| | | No. of Samples | 21 | 20 | 23 | 19 | 23 | 22 | 19 | 23 | 23 | 19 | 3 |
| | | | | | | | | | | | | | |
| | 300 | Average | (Median)<br>2,400 | 22 | 30 | 0.41 | 14 | 9.0 | 1.5 | 20 | 8.0 | 97 | 1.5 |
| | | Maximum | 24,000 | 26 | 110 | 1.1 | 24 | 11.2 | 3.6 | 47 | 8.4 | 101 | 1.6 |
| | | Minimum | 430 | 18 | 0 | 0.12 | 3 | 6.8 | 0.5 | 5 | 7.5 | 88 | 1.4 |
| | | No. of Samples | 15 | 13 | 16 | 15 | 16 | 15 | 14 | 16 | 16 | 12 | 3 |

Table 17 - SUMMARY OF AVERAGE ANALYTICAL RESULTS - LAKE ERIE (Cont'd)

| Sampling Range and Location | Station (Feet) | | Coliforms M.P.N. per 100ml. | Chlorides ppm | Phenols ppb | Ammonia as $N_2$ ppm | Temp. °C | D.O. ppm | B.O.D. 5 Day ppm | Turbidity ppm | pH | Alkalinity ppm | Total Iron ppm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UL (Cont'd) | 1,000 | Average | (Median) 1,900 | 22 | 49 | 0.33 | 15 | 9.4 | 1.2 | 13 | 8.1 | 94 | 1.1 |
| | | Maximum | 4,600 | 24 | 200 | 1.1 | 25 | 11.8 | 1.9 | 26 | 8.4 | 99 | 1.4 |
| | | Minimum | 230 | 19 | 0 | 0 | 4 | 7.6 | 0.5 | 2 | 7.6 | 87 | 1.0 |
| | | No. of Samples | 22 | 17 | 23 | 16 | 20 | 19 | 17 | 19 | 20 | 16 | 3 |
| | | | | | | | | | | | | | |
| | 2,000 | Average | (Median) 41 | 20 | 3 | 0.02 | 13 | 10.5 | 0.8 | 8 | 8.1 | 94 | 1.0 |
| | | Maximum | 2,400 | 25 | 25 | 0.16 | 23 | 13.4 | 1.9 | 22 | 8.5 | 96 | 1.2 |
| | | Minimum | < 3.0 | 18 | 0 | 0 | 3 | 8.4 | 0.2 | 1 | 7.7 | 87 | 0.7 |
| | | No. of Samples | 22 | 15 | 23 | 16 | 18 | 17 | 14 | 16 | 18 | 14 | 2 |
| | | | | | | | | | | | | | |
| | 3,000 | Average | (Median) 11 | 20 | 2 | 0 | 12 | 10.8 | 0.9 | 9 | 8.1 | 93 | |
| | | Maximum | 4,600 | 23 | 15 | 0.04 | 25 | 13.3 | 1.8 | 27 | 8.5 | 98 | |
| | | Minimum | < 3.0 | 18 | 0 | 0 | 2 | 8.6 | 0.2 | 1 | 7.7 | 84 | |
| | | No. of Samples | 17 | 14 | 18 | 15 | 17 | 12 | 11 | 17 | 17 | 13 | |
| | | | | | | | | | | | | | |
| | 4,000 | Average | (Median) 23 | 20 | 1 | 0.01 | 13 | 10.3 | 0.8 | 8 | 8.1 | 93 | |
| | | Maximum | 2,400 | 25 | 12 | 0.06 | 23 | 13.3 | 2.3 | 25 | 8.5 | 98 | |
| | | Minimum | < 3.0 | 14 | 0 | 0 | 2 | 8.3 | 0.2 | 1 | 7.7 | 87 | |
| | | No. of Samples | 21 | 17 | 22 | 17 | 20 | 15 | 14 | 20 | 20 | 16 | |
| | | | | | | | | | | | | | |
| WW A range south from South Pier Light over the Western New York Water Company intake, to point W, 1½ miles south of the intake | (Miles) | | | | | | | | | | | | |
| | 0 | | SOUTH PIER LIGHT | | | | | | | | | | |
| | 0.5 | Average | (Median) 8.2 | 19 | 1 | 0 | 14 | 12.4 | 1.2 | 3 | 8.4 | 94 | |
| | | Maximum | 93 | 23 | 3 | 0.01 | 21 | 13.0 | 1.6 | 5 | 8.6 | 96 | |
| | | Minimum | < 3.0 | 16 | 0 | 0 | 8 | 11.8 | 0.8 | 1 | 8.1 | 93 | |
| | | No. of Samples | 4 | 5 | 5 | 5 | 5 | 2 | 2 | 5 | 5 | 5 | |
| | | | | | | | | | | | | | |
| | 1.5 | Average | (Median) 29 | 20 | 1 | 0.01 | 14 | 12.4 | 1.3 | 4 | 8.3 | 93 | |
| | | Maximum | 43 | 23 | 6 | 0.01 | 21 | 13.0 | 1.6 | 5 | 8.5 | 96 | |
| | | Minimum | < 3.0 | 17 | 0 | 0 | 8 | 11.7 | 1.0 | 2 | 8.1 | 92 | |
| | | No. of Samples | 4 | 5 | 5 | 5 | 5 | 2 | 2 | 5 | 5 | 5 | |
| | | | | | | | | | | | | | |
| | 2.0 | Average | (Median) 23 | 21 | 1 | 0 | 15 | 12.5 | 1.6 | 4 | 8.3 | 93 | |
| | | Maximum | 93 | 23 | 4 | 0.02 | 21 | 13.0 | 1.8 | 6 | 8.5 | 96 | |
| | | Minimum | 0 | 18 | 0 | 0 | 8 | 12.0 | 1.4 | 2 | 8.1 | 90 | |
| | | No. of Samples | 5 | 5 | 5 | 5 | 5 | 2 | 2 | 5 | 5 | 5 | |
| | | | | | | | | | | | | | |
| | 2.5 (Intake) | Average | (Median) 7.3 | 20 | 2 | 0.01 | 15 | 12.5 | 1.2 | 4 | 8.3 | 94 | |
| | | Maximum | 460 | 22 | 4 | 0.04 | 21 | 13.0 | 1.6 | 6 | 8.5 | 95 | |
| | | Minimum | < 3.0 | 18 | 0 | 0 | 8 | 12.0 | 0.8 | 2 | 7.7 | 92 | |
| | | No. of Samples | 4 | 5 | 5 | 5 | 5 | 2 | 2 | 5 | 5 | 5 | |

Table 17 - SUMMARY OF AVERAGE ANALYTICAL RESULTS - LAKE ERIE (Cont'd)

| Sampling Range and Location | Station (Miles) | | Coliforms M.P.N. per 100ml. | Chlorides ppm | Phenols ppb | Ammonia as $N_2$ ppm | Temp. °C | D.O. ppm | B.O.D. 5 Day ppm | Turbidity ppm | pH | Alkalinity ppm | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| [illegible] (Cont'd) | 3.0 | Average | (Median) 16 | 20 | 2 | 0 | 15 | 12.5 | 1.0 | 4 | 8.3 | 94 | |
| | | Maximum | 1,100 | 22 | 6 | 0.01 | 21 | 12.9 | 1.3 | 5 | 8.5 | 96 | |
| | | Minimum | < 3.0 | 18 | 0 | 0 | 9 | 12.0 | 0.6 | 2 | 7.9 | 92 | |
| | | No. of Samples | 4 | 5 | 5 | 5 | 5 | 2 | 2 | 5 | 5 | 5 | |
| | 4.0 | | POINT W | | | | | | | | | | |
| | 4.0 | Average | (Median) 6.3 | 20 | 1 | 0.01 | 15 | 12.5 | 1.2 | 3 | 8.3 | 93 | |
| | | Maximum | > 1,100 | 23 | 4 | 0.06 | 21 | 12.9 | 1.8 | 6 | 8.7 | 96 | |
| | | Minimum | < 3.6 | 18 | 0 | 0 | 9 | 12.0 | 0.6 | 2 | 7.9 | 91 | |
| | | No. of Samples | 4 | 5 | 5 | 5 | 5 | 2 | 2 | 5 | 5 | 5 | |
| | (Feet) | | | | | | | | | | | | |
| 1W A range from the mouth of Smokes Creek, perpendicular to the United States shore | 0 | | UNITED STATES SHORE | | | | | | | | | | |
| | 0 | Average | (Median) 2,300 | 22 | 98 | 0.69 | 19 | 5.7 | 10.0 | 27 | 6.6 | 66 | |
| | | Maximum | 24,000 | 31 | 220 | 1.80 | 22 | 8.8 | 23.0 | 53 | 7.5 | 108 | |
| | | Minimum | 430 | 17 | 10 | 0.12 | 16 | 0 | 0.9 | 6 | 4.5 | 0 | |
| | | No. of Samples | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | |
| | 100 | Average | (Median) 430 | 21 | 50 | 0.16 | 18 | 8.0 | 3.1 | 30 | 7.3 | 81 | |
| | | Maximum | 2,400 | 24 | 110 | 0.24 | 21 | 9.5 | 7.6 | 64 | 7.8 | 93 | |
| | | Minimum | 150 | 19 | Trace | 0.04 | 16 | 7.0 | 0.6 | 6 | 6.8 | 67 | |
| | | No. of Samples | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | |
| | 400 | Average | (Median) 1,415 | 20 | 62 | 0.16 | 17 | 8.1 | 1.5 | 20 | 7.4 | 84 | |
| | | Maximum | 4,600 | 25 | 148 | 0.24 | 20 | 9.5 | 4.1 | 74 | 7.7 | 93 | |
| | | Minimum | 23 | 16 | 3 | 0.01 | 16 | 6.8 | 0.1 | 4 | 6.8 | 67 | |
| | | No. of Samples | 6 | 6 | 6 | 6 | 6 | 5 | 5 | 6 | 6 | 6 | |
| | 2,000 | Average | (Median) 43 | 19 | 39 | 0.02 | 16 | 9.5 | 0.5 | 5 | 7.9 | 94 | |
| | | Maximum | 930 | 22 | 148 | 0.06 | 20 | 10.3 | 0.9 | 7 | 8.3 | 96 | |
| | | Minimum | < 3.0 | 17 | 0 | 0 | 12 | 8.7 | 0.2 | 3 | 7.3 | 91 | |
| | | No. of Samples | 5 | 6 | 6 | 6 | 6 | 6 | 5 | 6 | 6 | 6 | |
| | 5,000 | Average | (Median) 9.1 | 19 | 2 | 0 | 15 | 9.7 | 0.5 | 3 | 8.2 | 95 | |
| | | Maximum | 23 | 22 | 6 | Trace | 18 | 10.6 | 0.8 | 4 | 8.4 | 97 | |
| | | Minimum | < 3.0 | 17 | 0 | 0 | 12 | 8.5 | 0.2 | 2 | 7.7 | 94 | |
| | | No. of Samples | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | |
| 2W A range from the mouth of drainage ditch at south boundary of Bethlehem Steel property, perpendicular to United States shore | 0 | | UNITED STATES SHORE | | | | | | | | | | |
| | 0 | Average | (Median) 650 | 31 | 74 | 0.89 | 25 | 4.7 | 8.1 | 47 | 5.6 | - | |
| | | Maximum | 4,300 | 75 | 150 | 3.2 | 28 | 9.6 | > 21 | 134 | 7.1 | 79 | |
| | | Minimum | < 3.0 | 18 | 3 | 0.24 | 20 | 0 | 3.1 | 8 | 3.0 | Acidity 2,348 | |
| | | No. of Samples | 8 | 6 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 7 | |

Table 17 - SUMMARY OF AVERAGE ANALYTICAL RESULTS - LAKE ERIE (Cont'd)

| Sampling Range and Location | Station (Feet) | | Coliforms M.P.N. per 100ml. | Chlorides ppm | Phenols ppb | Ammonia as $N_2$ ppm | Temp. °C | D.O. ppm | B.O.D. 5 Day ppm | Turbidity ppm | pH | Alkalinity ppm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2E (Cont'd) | 400 | Average | (Median) 490 | 20 | 26 | 0.04 | 17 | 8.8 | 0.8 | 8 | 7.6 | 90 |
| | | Maximum | 2,400 | 23 | 112 | 0.10 | 21 | 9.3 | 1.1 | 15 | 8.1 | 95 |
| | | Minimum | 43 | 17 | 0 | 0 | 16 | 8.4 | 0.3 | 4 | 7.2 | 85 |
| | | No. of Samples | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| | 2,500 | Average | (Median) 43 | 19 | 12 | 0.01 | 15 | 9.5 | 0.5 | 5 | 7.9 | 93 |
| | | Maximum | 430 | 21 | 45 | 0.02 | 18 | 10.0 | 0.8 | 8 | 8.1 | 96 |
| | | Minimum | 7.8 | 17 | 0 | Trace | 12 | 9.0 | 0.3 | 3 | 7.3 | 87 |
| | | No. of Samples | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| | 4,500 | Average | (Median) 6.3 | 20 | 1 | 0.05 | 16 | 9.4 | 0.4 | 3 | 8.0 | 94 |
| | | Maximum | 75 | 21 | 4 | 0.28 | 20 | 10.3 | 0.5 | 3 | 8.3 | 96 |
| | | Minimum | 3 | 17 | 0 | 0 | 12 | 8.8 | 0.2 | 2 | 7.5 | 90 |
| | | No. of Samples | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| 3E A range from the mouth of Rush Creek, perpendicular to United States shore | 0 | | UNITED STATES SHORE | | | | | | | | | |
| | 0 | Average | (Median) 240,000 | 51 | 48 | 5.4 | 15 | 2.3 | 21.1 | 32 | 7.2 | 211 |
| | | Maximum | 11,000,000 | 72 | 128 | 19.0 | 19 | 7.6 | 69 | 93 | 7.6 | 277 |
| | | Minimum | 910 | 18 | 4 | 0.16 | 11 | 0 | 6.3 | 5 | 6.7 | 158 |
| | | No. of Samples | 7 | 7 | 7 | 7 | 7 | 7 | 6 | 7 | 7 | 7 |
| | 400 | Average | (Median) 5,520 | 21 | 1 | 0.09 | 16 | 9.4 | 0.6 | 4 | 7.9 | 93 |
| | | Maximum | 460,000 | 22 | 4 | 0.30 | 18 | 9.9 | 0.8 | 6 | 8.1 | 94 |
| | | Minimum | < 30 | 18 | 0 | 0 | 12 | 9.0 | 0.3 | 2 | 7.5 | 90 |
| | | No. of Samples | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| | 2,000 | Average | (Median) 390 | 20 | 7 | 0.02 | 15 | 9.4 | 0.6 | 5 | 8.0 | 93 |
| | | Maximum | 930 | 22 | 20 | 0.06 | 18 | 10.1 | 1.1 | 10 | 8.1 | 95 |
| | | Minimum | 9.1 | 17 | 0 | 0 | 11 | 8.8 | 0.3 | 3 | 7.9 | 91 |
| | | No. of Samples | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| 4E A range from the Wanakah Water Company property perpendicular to United States shore | 0 | | UNITED STATES SHORE | | | | | | | | | |
| | 50 | Average | (Median) 430 | 17 | 0 | 0 | 16 | 10.3 | 0.4 | 3 | 8.1 | 93 |
| | | Maximum | 430 | 18 | 0 | 0 | 17 | 10.3 | 0.4 | 3 | 8.1 | 94 |
| | | Minimum | 430 | 16 | 0 | 0 | 14 | 10.2 | 0.4 | 2 | 8.1 | 92 |
| | | No. of Samples | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| | 325 | Average | (Median) 870 | 18 | 0 | 0 | 16 | 10.0 | 0.4 | 3 | 8.1 | 93 |
| | | Maximum | 1,500 | 19 | 0 | 0 | 17 | 10.2 | 0.4 | 3 | 8.1 | 93 |
| | | Minimum | 240 | 17 | 0 | 0 | 15 | 9.7 | 0.3 | 2 | 8.1 | 93 |
| | | No. of Samples | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |

Table 17 - SUMMARY OF AVERAGE ANALYTICAL RESULTS - LAKE ERIE (Cont'd)

| Sampling Range and Location | Station (Feet) | | Coliforms M.P.N. per 100ml. | Chlorides ppm | Phenols ppb | Ammonia as $N_2$ ppm | Temp. °C | D.O. ppm | B.O.D. 5 Day ppm | Turbidity ppm | pH | Alkalinity ppm | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4E (Cont'd) | 2,000 | Average | (Median) 68 | 17 | 0 | 0 | 17 | 9.4 | 0.2 | 3 | 8.1 | 96 | |
| | | Maximum | 93 | 19 | 0 | 0 | 18 | 9.4 | 0.2 | 3 | 8.1 | 97 | |
| | | Minimum | 43 | 15 | 0 | 0 | 15 | 9.3 | 0.2 | 2 | 8.1 | 94 | |
| | | No. of Samples | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | |
| 1W A range from Rose Hill Point, perpendicular to Canadian shore | 0 | | CANADIAN | SHORE | | | | | | | | | |
| | 200 | Average | (Median) 12 | | 6 | | | | | | | | |
| | | Maximum | 23 | | 25 | | | | | | | | |
| | | Minimum | < 3.0 | | 0 | | | | | | | | |
| | | No. of Samples | 4 | | 4 | | | | | | | | |
| | 600 | Average | (Median) 18 | 21 | 1 | 0 | 16 | 9.6 | 1.7 | 2 | 8.1 | 91 | |
| | | Maximum | 23 | 24 | 3 | 0 | 25 | 10.3 | 4.0 | 5 | 8.2 | 94 | |
| | | Minimum | 3.6 | 17 | 0 | 0 | 11 | 8.5 | 0.2 | 1 | 8.0 | 90 | |
| | | No. of Samples | 6 | 6 | 6 | 3 | 6 | 6 | 5 | 6 | 5 | 6 | |
| | 1,000 | Average | (Median) 4.9 | | 0 | | | | | | | | |
| | | Maximum | 23 | | 0 | | | | | | | | |
| | | Minimum | < 3.0 | | 0 | | | | | | | | |
| | | No. of Samples | 6 | | 6 | | | | | | | | |
| | 1,500 | Average | (Median) 1.5 | 21 | 0 | 0 | 15 | 9.9 | 1.6 | 2 | 8.1 | 89 | |
| | | Maximum | > 1,500 | 24 | 0 | 0 | 20.5 | 11.3 | 2.6 | 4 | 8.2 | 90 | |
| | | Minimum | < 3.0 | 18 | 0 | 0 | 11 | 8.4 | 0.3 | 1 | 8.1 | 88 | |
| | | No. of Samples | 6 | 5 | 6 | 2 | 5 | 5 | 4 | 5 | 4 | 5 | |
| | 2,000 | Average | (Median) 1.8 | | 1 | | | | | | | | |
| | | Maximum | 23 | | 3 | | | | | | | | |
| | | Minimum | < 3.0 | | 0 | | | | | | | | |
| | | No. of Samples | 6 | | 6 | | | | | | | | |
| | 2,500 | Average | (Median) < 3.0 | 24 | 0 | 0.01 | 23 | 8.6 | 2.6 | 1 | 8.1 | 91 | |
| | | Maximum | 23 | 24 | 0 | 0.02 | 25 | 8.7 | 5.0 | 1 | 8.1 | 92 | |
| | | Minimum | < 3.0 | 23 | 0 | 0 | 21 | 8.5 | 0.2 | 1 | 8.1 | 90 | |
| | | No. of Samples | 5 | 2 | 5 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | |
| 2W A range from Windmill Point perpendicular to Canadian shore | 0 | | CANADIAN | SHORE | | | | | | | | | |
| | 200 | Average | (Median) 3.3 | | 1 | 0.02 | 10 | 10.6 | 0.5 | 5 | 8.0 | | |
| | | Maximum | 23 | | 5 | 0.03 | 10 | 10.7 | 0.5 | 8 | 8.1 | | |
| | | Minimum | < 3.0 | | 0 | 0 | 10 | 10.4 | 0.4 | 2 | 7.9 | | |
| | | No. of Samples | 6 | | 6 | 2 | 2 | 2 | 2 | 2 | 2 | | |

# Table 17 - SUMMARY OF AVERAGE ANALYTICAL RESULTS - LAKE ERIE (Cont'd)

| Sampling Range and Location | Station (Feet) | | Coliforms M.P.N. per 100ml. | Chlorides ppm | Phenols ppb | Ammonia as $N_2$ ppm | Temp. °C | D.O. ppm | B.O.D. 5 Day ppm | Turbidity ppm | pH | Alkalinity ppm | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2W (Cont'd) | 600 | Average | (Median) 3.6 | 21 | 0 | 0 | 15 | 9.7 | 1.2 | 2 | 8.1 | 90 | |
| | | Maximum | 23 | 24 | 3 | 0 | 25 | 10.6 | 2.9 | 5 | 8.1 | 92 | |
| | | Minimum | < 3.0 | 17 | 0 | 0 | 10 | 8.4 | 0.3 | 1 | 7.9 | 86 | |
| | | No. of Samples | 8 | 6 | 8 | 5 | 8 | 8 | 7 | 8 | 7 | 6 | |
| | 1,000 | Average | (Median) < 3.0 | | 3 | 0 | 10 | 10.5 | 0.6 | 3 | 8.0 | | |
| | | Maximum | 23 | | 20 | 0 | 10 | 10.6 | 0.7 | 4 | 8.1 | | |
| | | Minimum | < 3.0 | | 0 | 0 | 10 | 10.3 | 0.4 | 2 | 7.9 | | |
| | | No. of Samples | 8 | | 8 | 2 | 2 | 2 | 2 | 2 | 2 | | |
| | 1,500 | Average | (Median) < 3.0 | 20 | 2 | 0 | 14 | 9.9 | 0.9 | 3 | 8.1 | 89 | |
| | | Maximum | 23 | 23 | 8 | 0 | 20 | 10.5 | 2.0 | 5 | 8.3 | 92 | |
| | | Minimum | < 3.0 | 17 | 0 | 0 | 10 | 9.3 | 0.4 | 1 | 7.9 | 84 | |
| | | No. of Samples | 8 | 5 | 8 | 4 | 7 | 7 | 6 | 7 | 6 | 5 | |
| | 2,000 | Average | (Median) 1.8 | | 1 | 0 | 10 | 10.4 | 0.6 | 3 | 8.0 | | |
| | | Maximum | 3.6 | | 5 | 0 | 10 | 10.5 | 0.6 | 4 | 8.1 | | |
| | | Minimum | < 3.0 | | 0 | 0 | 10 | 10.2 | 0.5 | 2 | 7.9 | | |
| | | No. of Samples | 8 | | 8 | 2 | 2 | 2 | 2 | 2 | 2 | | |
| | 2,500 | Average | (Median) < 3.0 | 24 | 0 | 0 | 22 | 8.7 | 1.0 | 1 | 8.2 | 90 | |
| | | Maximum | 240 | 24 | 0 | 0 | 24 | 8.7 | 1.5 | 1 | 8.3 | 90 | |
| | | Minimum | < 3.0 | 23 | 0 | 0 | 20 | 8.6 | 0.5 | 1 | 8.1 | 90 | |
| | | No. of Samples | 5 | 2 | 5 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | |
| 3W A range from Crystal Beach Pier, perpendicular to Canadian shore | 0 | | CANADIAN SHORE | | | | | | | | | | |
| | 200 | Average | (Median) 3.6 | 25 | 1 | 0 | 15 | 9.9 | 0.7 | 2 | 8.1 | 92 | |
| | | Maximum | 9.1 | 25 | 5 | 0 | 25 | 10.7 | 1.2 | 3 | 8.3 | 92 | |
| | | Minimum | < 3.0 | 25 | 0 | 0 | 10 | 8.5 | 0.5 | 2 | 7.9 | 92 | |
| | | No. of Samples | 7 | 1 | 7 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | |
| | 600 | Average | (Median) 6.3 | 21 | 0 | 0 | 15 | 9.8 | 0.7 | 2 | 8.1 | 90 | |
| | | Maximum | 460 | 24 | 3 | 0.02 | 25 | 10.6 | 1.5 | 5 | 8.3 | 92 | |
| | | Minimum | < 3.0 | 17 | 0 | 0 | 10 | 8.7 | 0.3 | 1 | 7.9 | 90 | |
| | | No. of Samples | 8 | 6 | 8 | 5 | 8 | 8 | 7 | 8 | 6 | 6 | |
| | 1,000 | Average | (Median) < 3.6 | | 1 | 0 | 10 | 10.5 | 0.5 | 3 | 8.0 | | |
| | | Maximum | 23 | | 5 | 0 | 10 | 10.6 | 0.5 | 3 | 8.1 | | |
| | | Minimum | < 3.0 | | 0 | 0 | 10 | 10.3 | 0.4 | 2 | 7.9 | | |
| | | No. of Samples | 8 | | 8 | 2 | 2 | 2 | 2 | 2 | 2 | | |

## Table 17 - SUMMARY OF AVERAGE ANALYTICAL RESULTS - LAKE ERIE (Cont'd)

| Sampling Range and Location | Station (Feet) | | Coliforms M.P.N. per 100ml. | Chlorides ppm | Phenols ppb | Ammonia as $N_2$ ppm | Temp. °C | D.O. ppm | B.O.D. 5 Day ppm | Turbidity ppm | pH | Alkalinity ppm | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3W (Cont'd) | 1,500 | Average | (Median) < 3.0 | 21 | 1 | 0 | 14 | 9.8 | 0.5 | 3 | 8.1 | 89 | |
| | | Maximum | 3.6 | 23 | 5 | 0 | 20 | 10.5 | 1.4 | 5 | 8.3 | 92 | |
| | | Minimum | < 8.0 | 18 | 0 | 0 | 10 | 8.9 | 0 | 1 | 7.9 | 85 | |
| | | No. of Samples | 8 | 5 | 8 | 4 | 7 | 7 | 7 | 7 | 6 | 5 | |
| | | | | | | | | | | | | | |
| | 2,000 | Average | (Median) 3.6 | | 1 | 0 | 10 | 10.4 | 0.4 | 3 | 8.0 | | |
| | | Maximum | 43 | | 5 | 0 | 10 | 10.5 | 0.4 | 3 | 8.1 | | |
| | | Minimum | < 3.0 | | 0 | 0 | 10 | 10.2 | 0.3 | 2 | 7.9 | | |
| | | No. of Samples | 8 | | 7 | 2 | 2 | 2 | 2 | 2 | 2 | | |
| | | | | | | | | | | | | | |
| | 2,500 | Average | (Median) < 3.0 | 24 | 0 | 0 | 23 | 8.6 | 0.5 | 1 | 8.1 | 89 | |
| | | Maximum | 23 | 24 | 0 | 0 | 25 | 8.8 | 0.7 | 1 | 8.1 | 90 | |
| | | Minimum | < 3.0 | 23 | 0 | 0 | 20 | 8.3 | 0.2 | 1 | 8.1 | 88 | |
| | | No. of Samples | 5 | 2 | 5 | 2 | 2 | 2 | 2 | 2 | 1 | 2 | |
| | | | | | | | | | | | | | |
| | (Miles) | | | | | | | | | | | | |
| P-1W A range from point "P" on the United States shore thru Seneca Shoal light to Rose Hill Point, Ontario (1W) | 0 | | UNITED STATES SHORE | | | | | | | | | | |
| | 1.0 | Average | (Median) 3.6 | 24 | 0 | 0 | 23 | 8.6 | 1.0 | 1 | 8.3 | 90 | |
| | | Maximum | 9.1 | 25 | 0 | 0 | 24.5 | 8.9 | 1.3 | 1 | 8.5 | 92 | |
| | | Minimum | < 3.0 | 22 | 0 | 0 | 20 | 8.3 | 0.4 | 1 | 8.1 | 88 | |
| | | No. of Samples | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | |
| | | | | | | | | | | | | | |
| | 2.0 | Average | (Median) 1.8 | 23 | 0 | 0 | 22 | 8.7 | 0.7 | 1 | 8.2 | 91 | |
| | | Maximum | 9.1 | 25 | 0 | 0 | 24 | 9.0 | 1.5 | 1 | 8.5 | 94 | |
| | | Minimum | < 3.0 | 22 | 0 | 0 | 19.5 | 8.3 | 0.3 | 1 | 8.1 | 88 | |
| | | No. of Samples | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | |
| | | | | | | | | | | | | | |
| | 3.0 | Average | (Median) < 3.0 | 26 | 0 | 0 | 23.5 | 8.6 | 1.6 | 1 | 8.2 | 88 | |
| | | Maximum | 23 | 26 | 0 | 0 | 23.5 | 8.6 | 1.6 | 1 | 8.2 | 88 | |
| | | Minimum | < 3.0 | 26 | 0 | 0 | 23.5 | 8.6 | 1.6 | 1 | 8.2 | 88 | |
| | | No. of Samples | 5 | 1 | 5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| | 3.5 | | SENECA SHOAL | | | | | | | | | | |
| | 4.0 | Average | (Median) 3.6 | | 0 | | | | | | | | |
| | | Maximum | 9.1 | | 0 | | | | | | | | |
| | | Minimum | < 3.0 | | 0 | | | | | | | | |
| | | No. of Samples | 5 | | 5 | | | | | | | | |
| | | | | | | | | | | | | | |
| | 5.0 | Average | (Median) < 3.6 | 23 | 0 | 0 | 23 | 8.6 | 1.0 | 1 | 8.3 | 89 | |
| | | Maximum | 3.6 | 24 | 0 | 0 | 24 | 9.0 | 1.6 | 1 | 8.4 | 90 | |
| | | Minimum | < 3.0 | 23 | 0 | 0 | 21 | 8.4 | 0.7 | 1 | 8.1 | 88 | |
| | | No. of Samples | 5 | 3 | 5 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | |
| | 5.8 | | INTERNATIONAL BOUNDARY | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |

Table 17 - SUMMARY OF AVERAGE ANALYTICAL RESULTS - LAKE ERIE (Cont'd)

| Sampling Range and Location | Station (Miles) | | Coliforms M.P.N. per 100ml | Chlorides ppm | Phenols ppb | Ammonia as $N_2$ ppm | Temp. °C | D.O. ppm | B.O.D. 5 Day ppm | Turbidity ppm | pH | Alkalinity ppm | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P-1W (Cont'd) | 6.0 | Average | (Median)<br>3.6 | 25 | 0 | 0 | 18 | 9.6 | 0.9 | 1 | 8.2 | 90 | |
| | | Maximum | 9.1 | 25 | 0 | 0 | 18 | 9.6 | 0.9 | 1 | 8.2 | 90 | |
| | | Minimum | < 3.0 | 25 | 0 | 0 | 18 | 9.6 | 0.9 | 1 | 8.2 | 90 | |
| | | No. of Samples | 6 | 1 | 6 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| | | | | | | | | | | | | | |
| | 7.0 | Average | (Median)<br>6.3 | 23 | 1 | 0 | 23.5 | 8.3 | 1.5 | 1 | 8.2 | 90 | |
| | | Maximum | 43 | 23 | 6 | 0 | 23.5 | 8.3 | 1.5 | 1 | 8.2 | 90 | |
| | | Minimum | < 3.0 | 23 | 0 | 0 | 23.5 | 8.3 | 1.5 | 1 | 8.2 | 90 | |
| | | No. of Samples | 6 | 1 | 6 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| | | | | | | | | | | | | | |
| | 8.0 | Average | (Median)<br>3.6 | 23 | 1 | 0 | 22 | 8.9 | 0.8 | 1 | 8.4 | 91 | |
| | | Maximum | 15 | 24 | 6 | 0 | 24.5 | 9.5 | 1.2 | 1 | 8.5 | 92 | |
| | | Minimum | < 3.0 | 22 | 0 | 0 | 19.5 | 8.3 | 0.5 | 1 | 8.2 | 90 | |
| | | No. of Samples | 7 | 4 | 7 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | |
| | | | | | | | | | | | | | |
| | 9.0 | Average | (Median)<br>9.1 | 24 | 2 | 0 | 23 | 8.6 | 1.1 | 1 | 8.2 | 91 | |
| | | Maximum | 23 | 24 | 7 | 0 | 24.5 | 9.0 | 1.7 | 1 | 8.4 | 92 | |
| | | Minimum | < 3.0 | 23 | 0 | 0 | 20 | 8.3 | 0.4 | 1 | 8.1 | 90 | |
| | | No. of Samples | 6 | 4 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | |
| | | | | | | | | | | | | | |
| WD A range from point "W" to the Seneca Shoal light on bearing N 71°W | | | | | | | | | | | | | |
| | 0 | | UNITED STATES SHORE | | | | | | | | | | |
| | 0.4 | | POINT W | | | | | | | | | | |
| | 1.4 | Average | (Median)<br>< 3.6 | 20 | 39 | 0 | 15 | 12.4 | 1.2 | 3 | 8.4 | 94 | |
| | | Maximum | 240 | 23 | 160 | 0.01 | 21 | 12.9 | 1.7 | 6 | 8.6 | 96 | |
| | | Minimum | < 3.0 | 18 | 0 | 0 | 9 | 11.8 | 0.6 | 2 | 8.1 | 92 | |
| | | No. of Samples | 4 | 5 | 5 | 5 | 5 | 2 | 2 | 5 | 5 | 5 | |
| | | | | | | | | | | | | | |
| | 2.4 | Average | (Median)<br>< 3.6 | 21 | 9 | 0 | 15 | 12.4 | 1.1 | 3 | 8.4 | 94 | |
| | | Maximum | < 3.6 | 23 | 45 | 0.01 | 21 | 12.8 | 1.4 | 6 | 8.6 | 97 | |
| | | Minimum | < 3.0 | 18 | 0 | 0 | 8 | 11.9 | 0.7 | 2 | 8.1 | 92 | |
| | | No. of Samples | 4 | 5 | 5 | 5 | 5 | 2 | 2 | 5 | 5 | 5 | |
| | | | | | | | | | | | | | |
| | 3.4 | Average | (Median)<br>< 3.6 | 20 | 28 | 0 | 15 | 12.3 | 1.2 | 3 | 8.4 | 95 | |
| | | Maximum | 3.6 | 23 | 140 | 0.01 | 21 | 12.3 | 1.2 | 5 | 8.6 | 96 | |
| | | Minimum | < 3.0 | 18 | 0 | 0 | 8 | 12.3 | 1.1 | 2 | 8.1 | 93 | |
| | | No. of Samples | 4 | 5 | 5 | 5 | 5 | 2 | 2 | 5 | 5 | 5 | |
| | 3.8 | | SENECA SHOAL | | | | | | | | | | |
| | | | | | | | | | | | | | |
| LC A range from South Pier Light to Crystal Beach, Ontario, thence along beach for 12 miles on a line about 1000' from shore | 0 | | SOUTH PIER LIGHT | | | | | | | | | | |
| | 0.5 | Average | (Median)<br>6.3 | 23 | 2 | 0.01 | 15 | 10.3 | 1.4 | 6 | 8.2 | 93 | |
| | | Maximum | 1,100 | 26 | 10 | 0.06 | 23 | 13.4 | 3.3 | 18 | 8.5 | 96 | |
| | | Minimum | < 3.0 | 18 | 0 | 0 | 10 | 7.9 | 0.4 | 2 | 7.7 | 86 | |
| | | No. of Samples | 10 | 6 | 11 | 7 | 8 | 5 | 5 | 8 | 8 | 6 | |

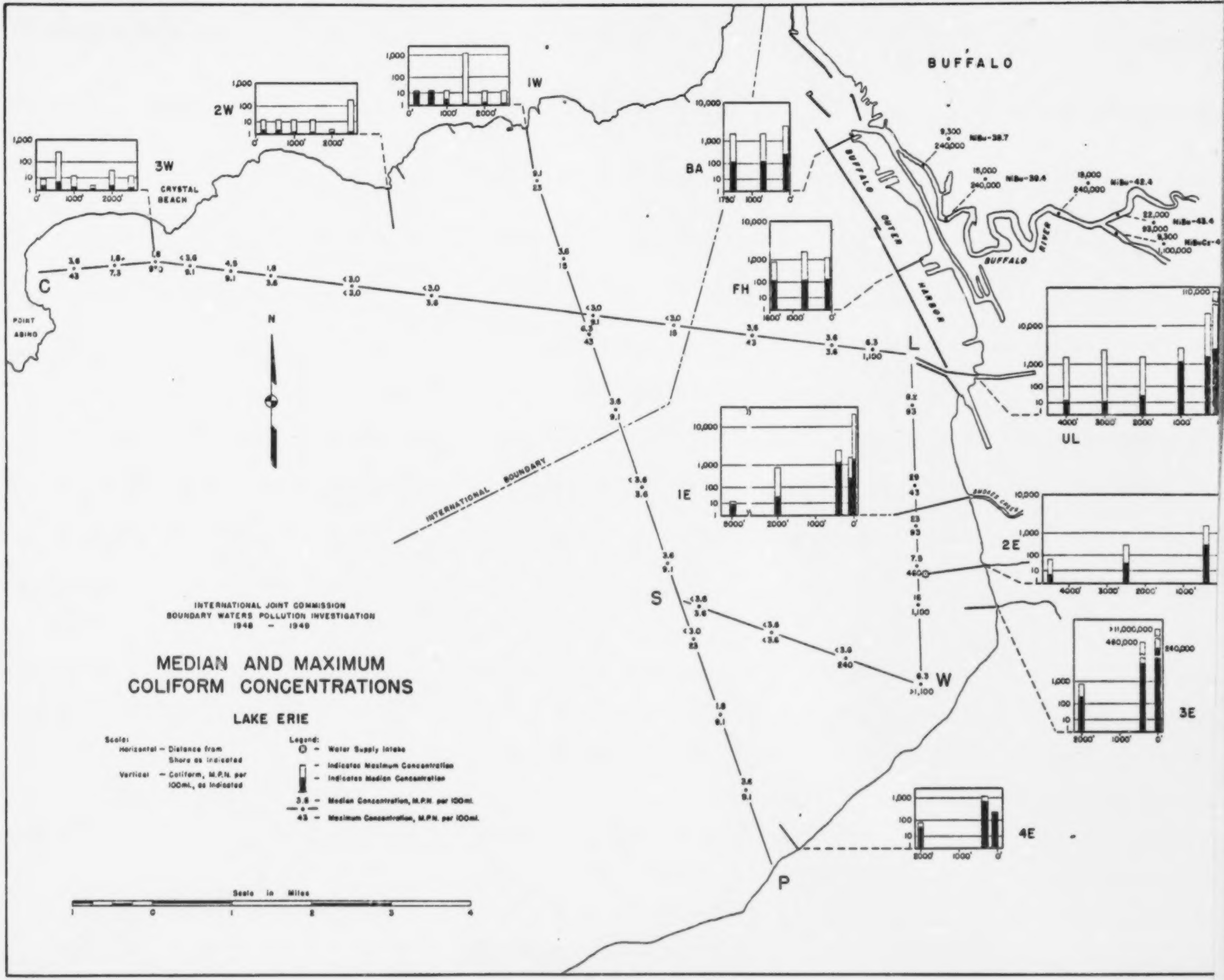
Table 17 - SUMMARY OF AVERAGE ANALYTICAL RESULTS - LAKE ERIE (Cont'd)

| Sampling Range and Location | Station (Miles) | | Coliforms M.P.N. per 100ml. | Chlorides ppm | Phenols ppb | Ammonia as $N_2$ ppm | Temp °C | D.O. ppm | B.O.D. 5 Day ppm | Turbidity ppm | pH | Alkalinity ppm | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LC (Cont'd) | 1.0 | Average | (Median)<br>3.6 | 22 | 2 | | 23 | 8.5 | 0.7 | 1 | 8.3 | 94 | |
| | | Maximum | 3.6 | 22 | 7 | | 23 | 8.5 | 0.7 | 1 | 8.3 | 94 | |
| | | Minimum | 3.0 | 22 | Trace | | 23 | 8.5 | 0.7 | 1 | 8.3 | 94 | |
| | | No. of Samples | 3 | 1 | 3 | | 1 | 1 | 1 | 1 | 1 | 1 | |
| | | | | | | | | | | | | | |
| | 2.0 | Average | (Median)<br>3.6 | 21 | 1 | 0 | 15 | 11.8 | 1.4 | 3 | 8.3 | 92 | |
| | | Maximum | 43 | 23 | 4 | 0.01 | 23 | 13.4 | 1.8 | 6 | 8.6 | 96 | |
| | | Minimum | < 3.0 | 18 | 0 | 0 | 10 | 10.8 | 1.0 | 1 | 7.9 | 83 | |
| | | No. of Samples | 10 | 5 | 10 | 6 | 7 | 3 | 4 | 7 | 7 | 5 | |
| | 2.8 | | INTERNATIONAL BOUNDARY | | | | | | | | | | |
| | 3.0 | Average | (Median)<br>< 3.0 | 23 | Trace | 0 | 22 | 8.6 | 0.8 | 1 | 8.1 | 92 | |
| | | Maximum | 15 | 23 | Trace | 0 | 23 | 8.7 | 1.8 | 1 | 8.3 | 96 | |
| | | Minimum | < 3.0 | [illegible] | 0 | 0 | 20 | 8.4 | 0.2 | 1 | 7.8 | 90 | |
| | | No. of Samples | 5 | 4 | [illegible] | 2 | 4 | 3 | 4 | 4 | 4 | 4 | |
| | | | | | | | | | | | | | |
| | 4.0 | Average | (Median)<br>< 3.0 | 21 | 1 | 0 | 13 | 12.1 | 1.1 | 4 | 8.3 | 93 | |
| | | Maximum | 9.1 | 22 | 3 | 0.01 | 20 | 13.7 | 1.7 | 7 | 8.6 | 95 | |
| | | Minimum | < 3.0 | 17 | 0 | 0 | 10 | 10.9 | 0.6 | 1 | 7.9 | 87 | |
| | | No. of Samples | 8 | 4 | 8 | 6 | 6 | 3 | 3 | 6 | 6 | 4 | |
| | | | | | | | | | | | | | |
| | 6.0 | Average | (Median)<br>< 3.0 | 21 | 2 | 0.01 | 13 | 11.7 | 0.8 | 3 | 8.2 | 94 | |
| | | Maximum | 3.6 | 22 | 6 | 0.03 | 20 | 13.2 | 1.1 | 5 | 8.5 | 97 | |
| | | Minimum | < 3.0 | 18 | 0 | 0 | 10 | 10.9 | 0.4 | 2 | 7.9 | 88 | |
| | | No. of Samples | 8 | 4 | 8 | 6 | 6 | 3 | 3 | 6 | 6 | 4 | |
| | | | | | | | | | | | | | |
| | 7.0 | Average | (Median)<br>< 3.0 | 19 | Trace | | 20 | 8.9 | 0.6 | 2 | | 90 | |
| | | Maximum | < 3.0 | 19 | Trace | | 20 | 8.9 | 0.6 | 2 | | 90 | |
| | | Minimum | < 3.0 | 19 | 0 | | 20 | 8.9 | 0.6 | 2 | | 90 | |
| | | No. of Samples | 2 | 1 | 2 | | 1 | 1 | 1 | 1 | | 1 | |
| | | | | | | | | | | | | | |
| | 8.0 | Average | (Median)<br>1.8 | 20 | 1 | 0 | 13 | 10.9 | 0.6 | 3 | 8.2 | 94 | |
| | | Maximum | 3.6 | 21 | 4 | Trace | 20 | 10.9 | 0.8 | 4 | 8.6 | 94 | |
| | | Minimum | < 3.0 | 18 | 0 | 0 | 10 | 10.8 | 0.3 | 2 | 7.9 | 94 | |
| | | No. of Samples | 8 | 3 | 7 | 5 | 5 | 2 | 2 | 5 | 5 | 3 | |
| | | | | | | | | | | | | | |
| | 8.5 | Average | (Median)<br>4.5 | 22 | Trace | | 23 | 8.7 | 0.7 | 2 | 8.3 | 92 | |
| | | Maximum | 9.1 | 23 | Trace | | 25 | 8.8 | 0.8 | 2 | 8.3 | 94 | |
| | | Minimum | < 3.0 | 21 | 0 | | 20 | 8.5 | 0.6 | 1 | 8.3 | 90 | |
| | | No. of Samples | 2 | 2 | 2 | | 2 | 2 | 2 | 2 | 1 | 2 | |
| | | | | | | | | | | | | | |
| | 9.0 | Average | (Median)<br>< 3.6 | 21 | 5 | 0 | 15 | 11.0 | 1.4 | 3 | 8.2 | 94 | |
| | | Maximum | 9.1 | 23 | 16 | 0.01 | 25 | 13.4 | 2.3 | 5 | 8.6 | 96 | |
| | | Minimum | < 3.0 | 18 | 0 | 0 | 10 | 8.8 | 0.8 | 2 | 7.9 | 87 | |
| | | No. of Samples | 8 | 5 | 8 | 6 | 7 | 4 | 4 | 7 | 7 | 5 | |

## Table 17 - SUMMARY OF AVERAGE ANALYTICAL RESULTS - LAKE ERIE (Cont'd)

| Sampling Range and Location | Station (Miles) | | Coliforms M.P.N. per 100ml. | Chlorides ppm | Phenols ppb | Ammonia as $N_2$ ppm | Temp. °C | D.O. ppm | B.O.D. 5 Day ppm | Turbidity ppm | pH | Alkalinity ppm | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LC (Cont'd) | 9.5 | | JUNCTION WITH RANGE | | | SW | | | | | | | |
| | 9.5 | Average | (Median) 1.8 | 21 | 2 | 0 | 13 | 11.4 | 0.7 | 3 | 8.2 | 95 | |
| | | Maximum | 930 | 22 | 8 | 0.01 | 20 | 12.6 | 0.8 | 6 | 8.5 | 98 | |
| | | Minimum | < 3.0 | 18 | 0 | 0 | 10 | 10.6 | 0.5 | 2 | 7.9 | 92 | |
| | | No. of Samples | 6 | 4 | 6 | 6 | 6 | 3 | 3 | 6 | 6 | 4 | |
| | | | | | | | | | | | | | |
| | 10.0 | Average | (Median) 1.8 | 20 | 12 | 0 | 13 | 11.7 | 0.7 | 3 | 8.2 | 94 | |
| | | Maximum | 7.3 | 21 | 55 | 0.01 | 20 | 13.1 | 0.8 | 4 | 8.6 | 97 | |
| | | Minimum | < 3.0 | 18 | 0 | 0 | 10 | 10.9 | 0.5 | 2 | 7.9 | 90 | |
| | | No. of Samples | 6 | 4 | 6 | 6 | 6 | 3 | 3 | 6 | 6 | 4 | |
| | | | | | | | | | | | | | |
| | 10.5 | Average | (Median) 3.6 | 21 | 71 | 0 | 13 | 11.7 | 0.9 | 4 | 8.2 | 94 | |
| | | Maximum | 43 | 22 | 400 | 0.01 | 20 | 12.9 | 1.0 | 6 | 8.6 | 97 | |
| | | Minimum | < 3.0 | 18 | 0 | 0 | 10 | 11.0 | 0.8 | 2 | 7.9 | 88 | |
| | | No. of Samples | 6 | 4 | 6 | 6 | 6 | 3 | 3 | 6 | 6 | 4 | |

124-A


BUFFALO
BUFFALO OUTER HARBOR
BUFFALO RIVER
9,300 • 240,000 NiBu-38.7
15,000 • 240,000 NiBu-39.4
19,000 • 240,000 NiBu-42.4
22,000 • 93,000 NiBu-43.4
9,300 • 1,100,000 NiBuCz-4
SMOKES CREEK
CRYSTAL BEACH
POINT ABINO
INTERNATIONAL BOUNDARY
N
C
L
S
W
P
3W
2W
1W
BA
FH
UL
1E
2E
3E
4E
3.6 • 43
1.8+ • 7.3
1.8 • 9.1
<3.6 • 9.1
4.5 • 9.1
1.8 • 3.6
<3.0 • <3.0
<3.0 • 3.6
<3.0 • 9.1
<3.0 • 15
3.6 • 43
3.6 • 3.6
6.3 • 1,100
9.1 • 23
3.6 • 15
6.3 • 43
3.6 • 9.1
<3.6 • 3.6
3.6 • 9.1
<3.6 • 3.6
<3.0 • 23
1.8 • 9.1
3.6 • 9.1
9.2 • 93
29 • 43
23 • 93
7.3 • 460
16 • 1,100
6.3 • >1,100
<3.6 • <3.6
<3.6 • 240
>11,000,000
460,000
240,000
110,000
10,000
1,000
100
10
1
0'
1000'
2000'
3000'
4000'
5000'
1600'
1750'
Scale in Miles
1
0
1
2
3
4

INTERNATIONAL JOINT COMMISSION
BOUNDARY WATERS POLLUTION INVESTIGATION
1948 – 1949

MEDIAN AND MAXIMUM
COLIFORM CONCENTRATIONS

LAKE ERIE

Scale:
Horizontal – Distance from Shore as Indicated
Vertical – Coliform, M.P.N. per 100ml., as Indicated

Legend:
Ⓞ – Water Supply Intake
▯ – Indicates Maximum Concentration
▮ – Indicates Median Concentration
3.6 – Median Concentration, M.P.N. per 100ml.
43 – Maximum Concentration, M.P.N. per 100ml.

FIGURE 3

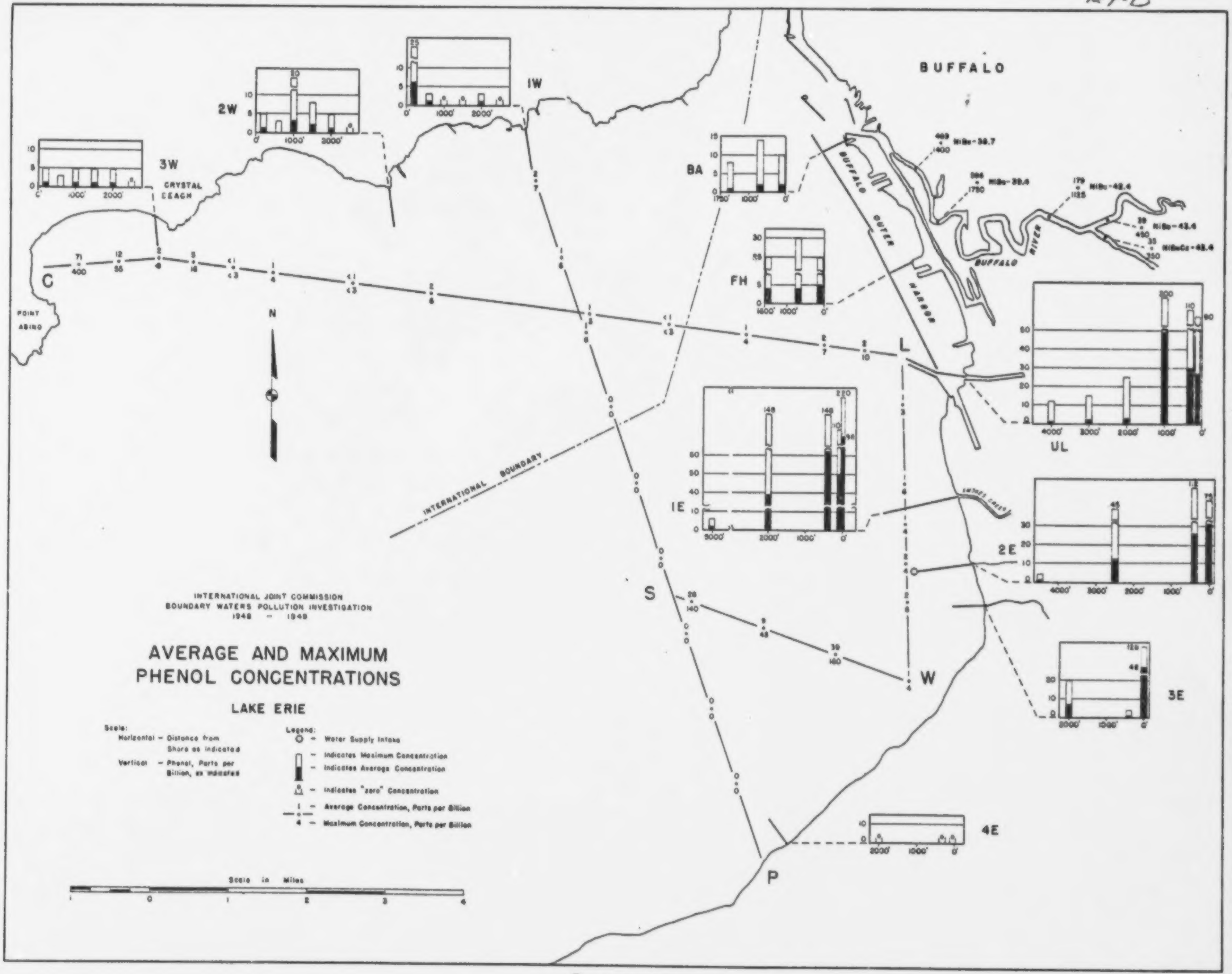

INTERNATIONAL JOINT COMMISSION
BOUNDARY WATERS POLLUTION INVESTIGATION
1948 – 1949
AVERAGE AND MAXIMUM
PHENOL CONCENTRATIONS
LAKE ERIE
Scale:
Horizontal – Distance from Shore as indicated
Vertical – Phenol, Parts per Billion, as indicated
Legend:
○ – Water Supply Intake
– Indicates Maximum Concentration
– Indicates Average Concentration
– Indicates "zero" Concentration
1 – Average Concentration, Parts per Billion
4 – Maximum Concentration, Parts per Billion
Scale in Miles
1 0 1 2 3 4
BUFFALO
BUFFALO OUTER HARBOR
BUFFALO RIVER
469 1400 MiBu-38.7
396 1750 MiBu-39.4
179 1125 MiBu-42.4
39 450 MiBu-43.4
35 350 MiBuCr-43.4
CRYSTAL BEACH
POINT ABINO
INTERNATIONAL BOUNDARY
SMOKES CREEK
N
C
L
S
W
P
3W
2W
1W
BA
FH
UL
1E
2E
3E
4E
71 400
12 55
2 8
5 16
<1 <3
1 4
2 6
2 7
2 10
28 140
9 45
39 160
200
110
90
148
220
98
45
126
48
25
20

FIGURE 4

## Upper Niagara River

The analytical results for the upper Niagara River are summarized in table 16. The more significant analyses, coliform M.P.N. median and maximum values are shown in figure 5, and phenol averages and maximums in figure 6.

The high velocity of flow in the upper Niagara River, mentioned in chapter IV, causes marked stratification within the river paralleling the shore. As a result, the unpolluted waters from the main body of Lake Erie remain separated under normal meteorological conditions from the flow in the easterly portion of the river. This easterly section is subject to pollution from the Buffalo River and harbor area, sewer outlets, and sewage treatment plant outfalls along the United States shore. The analyses of samples taken on ranges extending across the width of the river from its inlet to Grand Island and in the East and West Channels definitely revealed the pollution zone paralleling the shore. Furthermore, this pollution zone along the easterly portion of the river is marked by visible color and turbidity, part of which is due to surface run-off from tributaries.

This stratification of pollution, however, is influenced by meteorological conditions. For instance, strong southwesterly winds or seiches in Lake Erie may create an undertow which would tend to spread the pollution zone westerly by bringing pollution from the Buffalo River and the harbor area farther into the lake, and consequently, farther west from the United States shore in the Niagara River. Also, winds, ice jams, and heavy tributary run-offs along the river may modify the hydraulics and affect the limits of this zone of pollution. The river samples were taken under a variety of meteorological conditions during all seasons of the year. The summary of analytical results, therefore, represents the average of varying conditions of the river. It should be noted, however, that the river during the winter of 1948-49 was relatively free of ice, and that sampling during severe winds was not always possible.

The water entering the Niagara River is highly polluted along the United States shore, but is of good sanitary quality, similar to the main body of Lake Erie, on the westerly side. Above the river inlet the pollution originating from the Buffalo River and harbor area is mostly confined to the outer harbor which is bordered on the west by breakwaters paralleling the shore some 3,000 feet distant. Within the zone of pollution at the northern outlet of the outer harbor, the median coliform M.P.N. values were 7,500 per 100 ml. near the shore, decreasing to 59 per 100 ml. near the breakwater; the maximum was 110,000. Phenols, likewise, decreased from an average of 40 p.p.b. near the shore to 1 p.p.b. near the breakwater. The maximum phenol results ranged from 500 to 20 p.p.b.

That this pollution is due in part to the Buffalo River is indicated by the high median coliform M.P.N. of 9,300 per 100 ml., with a maximum of 240,000, and a high phenol average of 469 p.p.b. with a maximum of 1,400, found a short distance upstream from the mouth of the river. Similar high coliform values prevailed upstream beyond the Cazenovia Creek confluence with the Buffalo River. Phenols, however, were considerably reduced upstream with an average of about 40 p.p.b. at the Cazenovia Creek confluence. It should be noted that the sampling schedule for the Buffalo River permitted sampling only during the winter and spring months. While the concentrations of pollutants during the low river flows in the summer months are not shown, their effects were measured on the Niagara River ranges.

From the Niagara River inlet to a sampling range across the river at Strawberry Island (Ni - 32.5), the pollution zone is confined to the easterly portion of the river, gradually expanding westward during this course of flow downstream. The Black Rock Canal receives the heaviest concentration of pollutants since its location serves as a natural outlet from the Buffalo River and as a receiving stream for shore drainage and storm water overflows. The flow of sewage pollution into the canal is indicated by the median coliform M.P.N. of 15,000 per 100 ml., with a maximum of 240,000, found near the canal outlet. A large amount of the pollution follows the river on the west side of the canal breakwater, even though the concentration is not as great as in the canal. The pollution zone, based on the coliform results, extends about 500 feet from the shore of Bird Island on the United States side in the vicinity of Buffalo's sewage treatment plant, and it widens to about one-third the river's width near Strawberry Island. The median coliform content in this zone increased markedly downstream, with a median coliform M.P.N. of 4,450 per 100 ml. and a maximum of 110,000, found near the United States shore at the Strawberry Island range. Phenols were somewhat constant with a maximum average of 17 p.p.b. found offshore from Squaw Island at the International Railroad Bridge. The westerly portion of the river from the inlet to Strawberry Island exhibits average characteristics similar to the main body of Lake Erie except for moderate sewage pollution starting downstream from Fort Erie and extending a short distance from the Canadian shore.

The pollution originating in the Buffalo area was found to proceed down the East Channel of the river. This channel exhibits a marked pollution zone along the eastern shore, although pollution exists to some extent over its entire width. This pollution zone, as measured by both coliform and phenol results, extends along the entire channel usually varying from about one-third to one-half the channel width. Within this zone the median coliform M.P.N. varied from about 3,000 to 10,000 per 100 ml., with a maximum of 110,000, with no discernible trend in values downstream. Phenols generally average between 10 and 50 p.p.b. but reached as high an average as 140 p.p.b. near the easterly shore below the Tonawandas. Although the concentration of pollutants shows somewhat the effect of wastes introduced along the Tonawanda area, the broadening of the affected zone in the river below the Tonawandas further reflects added pollution.

Oil pollution was noted on the surface of the water in the East Channel on several occasions during the course of the investigation. The oil at times extended to cover the width of the river. Efforts to locate the sources of such pollution were not successful.

The West Channel around Grand Island is of good sanitary quality. The coliform results reveal that the pollution originating along the Fort Erie shore was gradually dissipated. In general, the water was of the same quality as that in the main body of Lake Erie.

Table 18 - SUMMARY OF AVERAGE ANALYTICAL RESULTS - UPPER NIAGARA RIVER

| Sampling Range and Mileage Index | Distance from East Shore | | Coliforms M.P.N. per 100ml. | Chlorides ppm | Phenols ppb | Ammonia as N ppm | Temp. °C | D.O. ppm | B.O.D. 5 Day ppm | Turbidity ppm | pH | Alkalinity ppm | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| N1Bu-38.7 Buffalo River at Michigan Ave. Bridge, Buffalo, N.Y. | | | | | | | | | | | | | |
| | | Average | (Median)<br>9,300 | 46 | 469 | 0.71 | 8 | 7.3 | 14.4 | 52 | 6.9 | 66 | |
| | | Maximum | 240,000 | 161 | 1400 | 1.50 | 13 | 13.2 | 31.5 | 193 | 7.4 | 96 | |
| | | Minimum | 910 | 8 | 35 | 0.26 | 0 | 0 | 6.2 | 18 | 5.9 | 36 | |
| | | No. of Samples | 36 | 23 | 25 | 25 | 25 | 25 | 25 | 26 | 24 | 23 | |
| | | | | | | | | | | | | | |
| N1-37.7 A range across the river just below the confluence of the Buffalo and Niagara Rivers and Buffalo Harbor and in line with the City of Buffalo water intake | | | | | | | | | | | | | |
| | 0' | | UNITED STATES SHORE | | | | | | | | | | |
| | 200' | Average | (Median)<br>7,500 | 26 | 40 | 0.18 | 14 | 8.6 | 2.6 | 15 | 7.7 | 90 | |
| | | Maximum | 110,000 | 34 | 450 | 0.92 | 27 | 11.5 | 20.0 | 64 | 8.2 | 96 | |
| | | Minimum | 460 | 19 | 0 | 0.01 | 4 | 4.7 | 0.5 | 3 | 6.7 | 81 | |
| | | No. of Samples | 40 | 20 | 40 | 32 | 41 | 41 | 39 | 41 | 41 | 20 | |
| | | | | | | | | | | | | | |
| | 1000' | Average | (Median)<br>930 | 21 | 25 | 0.09 | 12 | 10.3 | 1.4 | 12 | 8.0 | 92 | |
| | | Maximum | >11,000 | 27 | 500 | 0.60 | 26 | 13.0 | 11.3 | 61 | 8.5 | 96 | |
| | | Minimum | 21 | 18 | 0 | 0 | 3 | 6.6 | 0.4 | 2 | 7.1 | 82 | |
| | | No. of Samples | 33 | 10 | 33 | 28 | 31 | 31 | 29 | 31 | 31 | 10 | |
| | | | | | | | | | | | | | |
| | 2000' | Average | (Median)<br>39 | 21 | 1 | 0.01 | 12 | 10.9 | 0.9 | 8 | 8.1 | 92 | |
| | | Maximum | 4,600 | 26 | 20 | 0.08 | 26 | 13.6 | 2.9 | 15 | 8.4 | 95 | |
| | | Minimum | < 3.0 | 18 | 0 | 0 | 3 | 7.9 | 0.2 | 1 | 7.5 | 86 | |
| | | No. of Samples | 38 | 11 | 39 | 28 | 33 | 33 | 31 | 33 | 33 | 11 | |
| | | | | | | | | | | | | | |
| | 3800' | Average | (Median)<br>43 | 20 | 1 | 0 | 11 | 11.1 | 0.8 | 6 | 8.0 | 93 | |
| | | Maximum | 2,400 | 24 | 4 | 0.04 | 25 | 13.7 | 4.3 | 22 | 8.5 | 95 | |
| | | Minimum | < 3.0 | 18 | 0 | 0 | 3 | 8.2 | 0.2 | 1 | 7.4 | 84 | |
| | | No. of Samples | 33 | 8 | 34 | 27 | 30 | 27 | 27 | 30 | 30 | 7 | |
| | | | | | | | | | | | | | |
| | 5800' | Average | (Median)<br>5.3 | 20 | 1 | 0 | 13 | 11.3 | 0.9 | 5 | 8.1 | 92 | |
| | | Maximum | 460 | 22 | 6 | 0.01 | 25 | 13.7 | 2.3 | 21 | 8.4 | 94 | |
| | | Minimum | < 3.0 | 18 | 0 | 0 | 3 | 8.3 | 0.4 | 1 | 7.7 | 84 | |
| | | No. of Samples | 25 | 8 | 25 | 20 | 24 | 12 | 12 | 24 | 24 | 8 | |
| | 6800' | | WATER INTAKE - CITY OF BUFFALO, N.Y. | | | | | | | | | | |
| | 6800' | Average | (Median)<br>3.6 | 21 | 1 | 0 | 14 | 10.5 | 0.7 | 4 | 8.1 | 92 | |
| | | Maximum | 36 | 25 | 14 | 0.01 | 25 | 13.6 | 1.7 | 11 | 8.4 | 100 | |
| | | Minimum | < 3.0 | 17 | 0 | 0 | 3 | 7.5 | 0 | 1 | 7.4 | 84 | |
| | | No. of Samples | 31 | 15 | 31 | 24 | 31 | 19 | 17 | 31 | 30 | 15 | |
| | 8000' | | INTERNATIONAL BOUNDARY | | | | | | | | | | |
| | 8800' | Average | (Median)<br>3.6 | 20 | 1 | 0 | 13 | 11.5 | 0.7 | 4 | 8.1 | 98 | |
| | | Maximum | 43. | 24 | 10 | 0.01 | 24 | 13.6 | 1.5 | 12 | 8.4 | 96 | |
| | | Minimum | < 3.0 | 17 | 0 | 0 | 3 | 8.4 | 0.3 | 1 | 7.4 | 84 | |
| | | No. of Samples | 31 | 8 | 31 | 21 | 24 | 12 | 11 | 24 | 24 | 8 | |
| | | | | | | | | | | | | | |

## Table 18 - SUMMARY OF AVERAGE ANALYTICAL RESULTS - UPPER NIAGARA RIVER (Cont'd)

| Sampling Range and Mileage Index | Distance from East Shore | | Coliforms M.P.N. per 100ml. | Chlorides ppm | Phenols ppb | Ammonia as $N_2$ ppm | Temp. °C | D.O. ppm | B.O.D. 5 Day ppm | Turbidity ppm | pH | Alkalinity ppm | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ni-37.7 (Cont'd) | 10,000' | Average | (Median)<br>3.6 | 20 | 2 | 0 | 12 | 11.5 | 0.8 | 5 | 8.1 | 93 | |
| | | Maximum | 43 | 22 | 14 | 0.01 | 24 | 13.7 | 2.6 | 13 | 8.4 | 96 | |
| | | Minimum | < 3.0 | 18 | 0 | 0 | 3 | 8.2 | 0.3 | 1 | 7.5 | 86 | |
| | | No. of Samples | 24 | 7 | 24 | 20 | 23 | 11 | 11 | 23 | 23 | 7 | |
| | | | | | | | | | | | | | |
| | 11,500' | Average | (Median)<br>9.1 | 21 | 2 | 0 | 14 | 10.5 | 0.7 | 5 | 8.1 | 91 | |
| | | Maximum | 1,100 | 24 | 25 | 0.01 | 25 | 13.7 | 1.8 | 16 | 8.4 | 95 | |
| | | Minimum | < 3.0 | 18 | 0 | 0 | 3 | 7.3 | 0.1 | 1 | 7.6 | 88 | |
| | | No. of Samples | 31 | 15 | 31 | 24 | 31 | 19 | 18 | 31 | 31 | 15 | |
| | 12,000' | | CANADIAN SHORE | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| Ni-35.2 A range across the river from the ferry dock on Bird Island to the Canadian shore | 0' | | WEST SHORE OF BIRD ISLAND | | | | | | | | | | |
| | 200' | Average | (Median)<br>150 | 22 | 3 | 0.03 | 17 | 9.2 | 1.2 | 7 | 8.0 | 92 | |
| | | Maximum | 11,000 | 27 | 20 | 0.18 | 25.5 | 12.1 | 3.0 | 28 | 8.4 | 94 | |
| | | Minimum | < 3.0 | 17 | 0 | 0 | 4 | 8.0 | 0.1 | 1 | 7.7 | 88 | |
| | | No. of Samples | 21 | 15 | 21 | 14 | 21 | 14 | 14 | 21 | 20 | 15 | |
| | | | | | | | | | | | | | |
| | 400' | Average | (Median)<br>9.1 | 20 | 1 | 0 | 16 | 9.7 | 0.9 | 5 | 8.1 | 93 | |
| | | Maximum | 930 | 24 | 12 | 0.02 | 25 | 12.1 | 1.4 | 20 | 8.4 | 96 | |
| | | Minimum | < 3.0 | 17 | 0 | 0 | 4 | 8.5 | 0.3 | 1 | 7.7 | 88 | |
| | | No. of Samples | 21 | 9 | 21 | 11 | 15 | 8 | 8 | 15 | 15 | 9 | |
| | | | | | | | | | | | | | |
| | 600' | Average | (Median)<br>3.6 | 21 | 1 | 0 | 16 | 9.5 | 0.8 | 6 | 8.1 | 92 | |
| | | Maximum | 93 | 24 | 10 | 0.03 | 24.5 | 12.1 | 1.6 | 64 | 8.5 | 94 | |
| | | Minimum | < 3.0 | 16 | 0 | 0 | 4 | 8.3 | 0.2 | 1 | 7.7 | 88 | |
| | | No. of Samples | 21 | 13 | 21 | 14 | 19 | 12 | 12 | 19 | 18 | 13 | |
| | 700' | | INTERNATIONAL BOUNDARY | | | | | | | | | | |
| | 1000' | Average | (Median)<br>8.1 | 20 | 0 | 0 | 16 | 9.5 | 0.9 | 5 | 8.1 | 93 | |
| | | Maximum | 93 | 22 | 3 | 0 | 25 | 12.3 | 1.9 | 17 | 8.5 | 97 | |
| | | Minimum | < 3.0 | 17 | 0 | 0 | 4 | 8.5 | 0.1 | 1 | 7.7 | 88 | |
| | | No. of Samples | 20 | 9 | 20 | 11 | 15 | 7 | 7 | 15 | 15 | 9 | |
| | | | | | | | | | | | | | |
| | 1400' | Average | (Median)<br>23 | 21 | 0 | 0 | 16 | 9.1 | 0.8 | 4 | 8.1 | 92 | |
| | | Maximum | 460 | 25 | 3 | 0.02 | 24 | 10.4 | 1.7 | 19 | 8.4 | 96 | |
| | | Minimum | < 3.0 | 18 | 0 | 0 | 4 | 8.4 | 0.2 | 1 | 7.7 | 86 | |
| | | No. of Samples | 21 | 15 | 21 | 14 | 21 | 12 | 12 | 21 | 21 | 15 | |
| | 1600' | | CANADIAN SHORE | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| NiBR-35.2<br>Black Rock Canal at Ferry Street Bridge, Buffalo, N.Y. | | Average | (Median)<br>4,300 | 23 | 13 | 0.29 | 6 | 10.2 | 2.2 | 18 | 7.6 | 93 | |
| | | Maximum | 150,000 | 32 | 45 | 1.20 | 16 | 13.2 | 6.4 | 31 | 7.9 | 121 | |
| | | Minimum | 910 | 19 | Trace | 0.01 | 0 | 5.6 | 0.9 | 5 | 7.3 | 84 | |
| | | No. of Samples | 24 | 10 | 17 | 17 | 17 | 16 | 16 | 17 | 16 | 10 | |

## Table 18 - SUMMARY OF AVERAGE ANALYTICAL RESULTS - UPPER NIAGARA RIVER (Cont'd)

| Sampling Range and Mileage Index | Distance from East Shore | | Coliforms M.P.N. per 100ml. | Chlorides ppm | Phenols ppb | Ammonia as $N_2$ ppm | Temp. °C | D.O. ppm | B.O.D. 5 Day ppm | Turbidity ppm | pH | Alkalinity ppm | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | |
| N1-34.3 A range across the river at the International R. R. Bridge below the Buffalo Sewer Authority treatment plant | 0' | | WEST SHORE OF SQUAW ISLAND | | | | | | | | | | |
| | 100' | Average | (Median) 2,400 | 25 | 17 | 0.08 | 10 | 10.7 | 1.5 | 13.6 | 7.8 | 92 | |
| | | Maximum | > 150,000 | 42 | 120 | 0.24 | 26 | 14.6 | 3.5 | 45 | 8.3 | 100 | |
| | | Minimum | 43 | 17 | 0 | 0.01 | 0 | 7.0 | 0.4 | 2.0 | 7.2 | 86 | |
| | | No. of Samples | 44 | 14 | 35 | 26 | 37 | 36 | 35 | 37 | 36 | 14 | |
| | | | | | | | | | | | | | |
| | 300' | Average | (Median) 1,500 | 22 | 8 | 0.08 | 8 | 11.7 | 1.6 | 14 | 7.8 | 92 | |
| | | Maximum | 46,000 | 24 | 70 | 0.20 | 24 | 14.8 | 3.2 | 41 | 8.3 | 96 | |
| | | Minimum | 30 | 19 | 0 | 0 | 0 | 7.8 | 0.3 | 1 | 7.5 | 88 | |
| | | No. of Samples | 44 | 6 | 35 | 25 | 29 | 29 | 27 | 29 | 29 | 6 | |
| | 400' | | INTERNATIONAL BOUNDARY | | | | | | | | | | |
| | 500' | Average | (Median) 430 | 22 | 10 | 0.03 | 7 | 12.0 | 0.9 | 13 | 7.9 | 95 | |
| | | Maximum | 24,000 | 29 | 150 | 0.12 | 24 | 14.7 | 2.4 | 35 | 8.4 | 98 | |
| | | Minimum | 9.1 | 17 | 0 | 0 | 0 | 8.0 | 0.3 | 1 | 7.5 | 92 | |
| | | No. of Samples | 35 | 5 | 26 | 24 | 28 | 28 | 28 | 28 | 28 | 5 | |
| | | | | | | | | | | | | | |
| | 700' | Average | (Median) 9.1 | 21 | 4 | 0.01 | 10 | 11.5 | 0.7 | 10 | 7.9 | 92 | |
| | | Maximum | > 1,100 | 31 | 40 | 0.10 | 24.5 | 14.6 | 2.0 | 32 | 8.4 | 96 | |
| | | Minimum | < 3.0 | 16 | 0 | 0 | 0 | 8.3 | 0.3 | 1 | 7.5 | 88 | |
| | | No. of Samples | 45 | 14 | 36 | 27 | 37 | 34 | 36 | 37 | 36 | 14 | |
| | | | | | | | | | | | | | |
| | 1000' | Average | (Median) 9.1 | 21 | 2 | 0 | 8 | 11.9 | 0.7 | 12 | 7.9 | 93 | |
| | | Maximum | 240 | 24 | 6 | 0.01 | 24 | 14.5 | 1.7 | 32 | 8.4 | 96 | |
| | | Minimum | < 3.0 | 18 | 0 | 0 | 0 | 8.2 | 0.2 | 1 | 7.5 | 88 | |
| | | No. of Samples | 34 | 5 | 26 | 23 | 24 | 18 | 22 | 27 | 27 | 5 | |
| | | | | | | | | | | | | | |
| | 1300' | Average | (Median) 9.1 | 21 | 3 | 0 | 8 | 12.1 | 0.6 | 12 | 7.9 | 94 | |
| | | Maximum | 93 | 26 | 16 | 0.01 | 24 | 14.4 | 1.7 | 26 | 8.5 | 96 | |
| | | Minimum | < 3.0 | 18 | 0 | 0 | 0 | 8.3 | 0 | 1 | 7.4 | 92 | |
| | | No. of Samples | 34 | 5 | 25 | 23 | 27 | 17 | 21 | 27 | 27 | 5 | |
| | | | | | | | | | | | | | |
| | 1600' | Average | (Median) 9.1 | 21 | 2 | 0 | 8 | 12.0 | 0.6 | 12 | 7.9 | 92 | |
| | | Maximum | 240 | 24 | 14 | 0.02 | 24 | 14.4 | 1.5 | 35 | 8.5 | 96 | |
| | | Minimum | < 3.0 | 17 | 0 | 0 | 0 | 8.3 | 0.2 | 1 | 7.5 | 86 | |
| | | No. of Samples | 44 | 6 | 34 | 24 | 28 | 18 | 22 | 28 | 28 | 6 | |
| | | | | | | | | | | | | | |
| | 1700' | Average | (Median) 23 | 21 | 4 | 0 | 10 | 11.3 | 0.8 | 11 | 7.9 | 92 | |
| | | Maximum | 210 | 23 | 50 | Trace | 24 | 14.4 | 2.8 | 50 | 8.3 | 98 | |
| | | Minimum | < 3.6 | 18 | 0 | 0 | 0 | 8.4 | 0.2 | 1 | 7.5 | 88 | |
| | | No. of Samples | 45 | 14 | 36 | 27 | 38 | 26 | 31 | 37 | 36 | 14 | |
| | 1800' | | CANADIAN SHORE | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |

Table 18 - SUMMARY OF AVERAGE ANALYTICAL RESULTS - UPPER NIAGARA RIVER (Cont'd)

| Sampling Range and Mileage Index | Distance from East Shore | | Coliforms M.P.N. per 100ml. | Chlorides ppm | Phenols ppb | Ammonia as N2 ppm | Temp. °C | D.O. ppm | B.O.D. 5 Day ppm | Turbidity ppm | pH | Alkalinity ppm | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NiBR-34.3 Black Rock Canal at International Bridge, Buffalo, N.Y. | | Average | (Median) 15,000 | 23 | 18 | 0.36 | 6 | 8.6 | 3.1 | 19 | 7.4 | 96 | |
| | | Maximum | 240,000 | 28 | 60 | 1.60 | 16 | 12.4 | 10.2 | 83 | 7.8 | 105 | |
| | | Minimum | 910 | 19 | Trace | 0.08 | 0 | 4.8 | 0.9 | 6 | 7.2 | 89 | |
| | | No. of Samples | 27 | 10 | 19 | 20 | 20 | 20 | 19 | 20 | 19 | 10 | |
| NiFr-32.6 Frenchmans Creek at confluence with upper Niagara River. | | Average | (Median) 1,470 | 16 | 2 | 0.08 | 4 | 9.9 | 2.6 | 55 | 7.5 | 78 | |
| | | Maximum | 2,400 | 27 | 5 | 0.08 | 6 | 12.2 | 3.7 | 110 | 8.1 | 122 | |
| | | Minimum | 540 | 5 | 0 | 0.08 | 1 | 7.2 | 2.0 | 15 | 7.2 | 32 | |
| | | No. of Samples | 4 | 4 | 4 | 1 | 3 | 4 | 4 | 4 | 4 | 4 | |
| Ni-32.5 A range across the river at the head of Strawberry Island | 0' | | UNITED STATES SHORE | | | | | | | | | | |
| | 100' | Average | (Median) 4,450 | 23 | 3 | 0.03 | 18 | 9.1 | 1.6 | 9 | 8.0 | 92 | |
| | | Maximum | 110,000 | 26 | 10 | 0.08 | 26 | 11.8 | 4.6 | 48 | 8.4 | 96 | |
| | | Minimum | 430 | 17 | 0 | 0 | 4 | 7.6 | 0.4 | 1 | 7.6 | 86 | |
| | | No. of Samples | 22 | 14 | 22 | 14 | 22 | 21 | 21 | 22 | 22 | 13 | |
| | 400' | Average | (Median) 4,300 | 23 | 2 | 0.04 | 18 | 9.2 | 1.5 | 8 | 8.1 | 92 | |
| | | Maximum | 46,000 | 26 | 12 | 0.10 | 25 | 11.7 | 4.5 | 43 | 8.4 | 96 | |
| | | Minimum | 91 | 18 | 0 | 0 | 4 | 7.8 | 0.5 | 1 | 7.6 | 86 | |
| | | No. of Samples | 23 | 14 | 23 | 14 | 22 | 21 | 21 | 22 | 22 | 13 | |
| | 700' | Average | (Median) 2,300 | 21 | 2 | 0.04 | 17 | 9.4 | 1.1 | 8 | 8.1 | 93 | |
| | | Maximum | 9,300 | 24 | 10 | 0.10 | 25 | 11.7 | 2.2 | 30 | 8.5 | 96 | |
| | | Minimum | < 3.0 | 18 | 0 | 0 | 4 | 8.2 | 0.2 | 1 | 7.6 | 88 | |
| | | No. of Samples | 19 | 11 | 19 | 11 | 19 | 19 | 18 | 19 | 19 | 10 | |
| | 1100' | Average | (Median) 230 | 21 | 1 | 0.02 | 17 | 9.5 | 0.8 | 6 | 8.1 | 92 | |
| | | Maximum | 9,300 | 26 | 8 | 0.06 | 25 | 11.9 | 2.4 | 32 | 8.5 | 96 | |
| | | Minimum | 3.6 | 17 | 0 | 0 | 4 | 8.4 | 0.2 | 1 | 7.5 | 88 | |
| | | No. of Samples | 21 | 12 | 21 | 13 | 20 | 19 | 18 | 20 | 20 | 11 | |
| | 1400' | Average | (Median) 93 | 20 | 1 | 0.01 | 17 | 9.2 | 0.7 | 5 | 8.2 | 93 | |
| | | Maximum | 11,000 | 25 | 3 | 0.08 | 25 | 11.0 | 1.8 | 26 | 8.5 | 96 | |
| | | Minimum | < 3.0 | 18 | 0 | 0 | 4 | 8.2 | 0.1 | 1 | 7.6 | 86 | |
| | | No. of Samples | 19 | 11 | 18 | 11 | 19 | 12 | 12 | 19 | 19 | 10 | |
| | 1700' | Average | (Median) 23 | 22 | 1 | 0.01 | 17 | 9.1 | 0.7 | 4 | 8.1 | 92 | |
| | | Maximum | 11,000 | 27 | 12 | 0.06 | 25 | 11.0 | 1.2 | 21 | 8.5 | 96 | |
| | | Minimum | 3.0 | 18 | 0 | 0 | 4 | 8.3 | 0 | 1 | 7.5 | 86 | |
| | | No. of Samples | 22 | 14 | 22 | 14 | 22 | 14 | 13 | 22 | 22 | 13 | |

## Table 18 - SUMMARY OF AVERAGE ANALYTICAL RESULTS - UPPER NIAGARA RIVER (Cont'd)

| Sampling Range and Mileage Index | Distance from East Shore | | Coliforms M.P.N. per 100ml. | Chlorides ppm | Phenols ppb | Ammonia as N2 ppm | Temp. °C | D.O. ppm | B.O.D. 5 Day ppm | Turbidity ppm | pH | Alkalinity ppm | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| N1-32.5 (Cont'd) | 2500' | Average | (Median) 9.1 | 21 | 1 | 0 | 17 | 9.1 | 1.0 | 3 | 8.1 | 92 | |
| | | Maximum | 240 | 26 | 3 | Trace | 25 | 11.1 | 3.9 | 14 | 8.6 | 95 | |
| | | Minimum | < 3.0 | 18 | 0 | 0 | 4 | 8.4 | 0 | 1 | 7.5 | 88 | |
| | | No. of Samples | 23 | 14 | 22 | 13 | 21 | 12 | 12 | 21 | 21 | 13 | |
| | 3000' | Average | (Median) 8.2 | 21 | 1 | 0 | 17 | 9.1 | 0.7 | 4 | 8.2 | 93 | |
| | | Maximum | 240 | 26 | 6 | Trace | 25 | 11.2 | 1.5 | 19 | 8.6 | 97 | |
| | | Minimum | < 3.0 | 18 | 0 | 0 | 4 | 8.3 | 0.2 | 1 | 7.5 | 88 | |
| | | No. of Samples | 22 | 13 | 22 | 13 | 21 | 13 | 12 | 21 | 21 | 12 | |
| | 3500' | Average | (Median) 9.1 | 21 | 1 | 0 | 17 | 9.2 | 0.6 | 4 | 8.2 | 93 | |
| | | Maximum | 360 | 27 | 4 | Trace | 25.5 | 11.3 | 1.0 | 17 | 8.5 | 97 | |
| | | Minimum | < 3.0 | 17 | 0 | 0 | 4 | 8.4 | 0.2 | 1 | 7.6 | 88 | |
| | | No. of Samples | 23 | 13 | 23 | 13 | 21 | 12 | 12 | 20 | 20 | 12 | |
| | 3600' | | INTERNATIONAL BOUNDARY | | | | | | | | | | |
| | 4500' | Average | (Median) 14.5 | 21 | 1 | 0 | 17 | 9.1 | 0.9 | 4 | 8.1 | 93 | |
| | | Maximum | 93 | 25 | 8 | Trace | 26 | 11.4 | 1.9 | 24 | 8.5 | 98 | |
| | | Minimum | < 3.0 | 17 | 0 | 0 | 4 | 7.5 | 0.1 | 1 | 7.5 | 88 | |
| | | No. of Samples | 22 | 14 | 22 | 14 | 22 | 14 | 13 | 22 | 22 | 13 | |
| | 5500' | Average | (Median) 30 | 22 | 0 | 0 | 17 | 9.1 | 1.5 | 4 | 8.2 | 93 | |
| | | Maximum | 15,000 | 26 | 6 | 0.01 | 26 | 11.2 | 3.0 | 21 | 8.5 | 96 | |
| | | Minimum | < 3.0 | 18 | 0 | 0 | 4 | 6.9 | 0.3 | 1 | 7.6 | 90 | |
| | | No. of Samples | 22 | 13 | 22 | 13 | 21 | 12 | 12 | 21 | 21 | 12 | |
| | 5900' | | CANADIAN SHORE | | | | | | | | | | |
| N1-29.0 A range across the East Channel at the South Grand Island Bridge | 0' | | UNITED STATES SHORE | | | | | | | | | | |
| | 100' | Average | (Median) 3,900 | 21 | 53 | 0.11 | 7 | 11.8 | 1.5 | 14 | 7.7 | 92 | |
| | | Maximum | 24,000 | 22 | 120 | 0.26 | 24 | 14.2 | 2.2 | 35 | 8.3 | 96 | |
| | | Minimum | 230 | 19 | 0 | 0 | 0 | 7.7 | 0.7 | 2 | 7.1 | 88 | |
| | | No. of Samples | 29 | 7 | 20 | 16 | 20 | 18 | 19 | 20 | 20 | 7 | |
| | 200' | Average | (Median) 4,300 | 22 | 15 | 0.07 | 11 | 10.9 | 1.4 | 11 | 7.8 | 92 | |
| | | Maximum | 24,000 | 26 | 90 | 0.24 | 24 | 14.4 | 2.5 | 35 | 8.3 | 96 | |
| | | Minimum | 430 | 18 | 0 | 0 | 0 | 7.2 | 0.6 | 1 | 7.3 | 90 | |
| | | No. of Samples | 35 | 14 | 27 | 22 | 27 | 24 | 25 | 27 | 25 | 14 | |
| | 300' | Average | (Median) 2,300 | 19 | 10 | 0.06 | 7 | 12.4 | 1.0 | 14 | 7.8 | 94 | |
| | | Maximum | 21,000 | 21 | 40 | 0.18 | 24 | 14.4 | 2.2 | 34 | 8.4 | 95 | |
| | | Minimum | 91 | 18 | 0 | 0 | 0 | 7.8 | 0.3 | 1 | 7.4 | 92 | |
| | | No. of Samples | 26 | 5 | 18 | 16 | 18 | 16 | 16 | 18 | 18 | 5 | |

Table 18 - SUMMARY OF AVERAGE ANALYTICAL RESULTS - UPPER NIAGARA RIVER (Cont'd)

| Sampling Range and Mileage Index | Distance from East Shore | | Coliforms M.P.N. per 100ml | Chlorides ppm | Phenols ppb | Ammonia as $N_2$ ppm | Temp. °C | D.O. ppm | B.O.D. 5 Day ppm | Turbidity ppm | pH | Alkalinity ppm | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| N1-29.0 (Cont'd) | 400' | Average | (Median) 1,900 | 19 | 5 | 0.03 | 8 | 12.0 | 0.9 | 14 | 7.8 | 93 | |
| | | Maximum | 15,000 | 21 | 70 | 0.06 | 24 | 14.6 | 1.7 | 35 | 8.4 | 96 | |
| | | Minimum | 43 | 18 | 0 | 0 | 0 | 8.0 | 0.3 | 1 | 7.4 | 90 | |
| | | No. of Samples | 34 | 7 | 26 | 15 | 19 | 17 | 18 | 19 | 19 | 7 | |
| | | | | | | | | | | | | | |
| | 600' | Average | (Median) 430 | 19 | 4 | 0.02 | 7 | 12.8 | 0.8 | 15 | 7.8 | 93 | |
| | | Maximum | 2,400 | 22 | 25 | 0.06 | 24 | 14.5 | 1.6 | 34 | 8.5 | 96 | |
| | | Minimum | 23 | 18 | 0 | 0 | 0 | 8.3 | 0.3 | 1 | 7.5 | 92 | |
| | | No. of Samples | 26 | 5 | 18 | 16 | 18 | 14 | 15 | 18 | 18 | 5 | |
| | | | | | | | | | | | | | |
| | 800' | Average | (Median) 230 | 21 | 4 | 0.01 | 11 | 11.1 | 0.8 | 11 | 7.9 | 92 | |
| | | Maximum | 4,600 | 25 | 75 | 0.08 | 24 | 14.5 | 3.6 | 34 | 8.5 | 96 | |
| | | Minimum | 7.3 | 17 | 0 | 0 | 0 | 8.0 | 0.2 | 1 | 7.5 | 88 | |
| | | No. of Samples | 35 | 13 | 27 | 22 | 27 | 18 | 22 | 26 | 25 | 14 | |
| | | | | | | | | | | | | | |
| | 1100' | Average | (Median) 43 | 19 | 2 | 0.01 | 7 | 13.5 | 0.6 | 14 | 7.8 | 94 | |
| | | Maximum | 1,100 | 22 | 25 | 0.04 | 23 | 14.5 | 1.5 | 30 | 8.5 | 95 | |
| | | Minimum | < 3.0 | 18 | 0 | 0 | 0 | 8.0 | 0.1 | 1 | 7.5 | 92 | |
| | | No. of Samples | 35 | 5 | 27 | 16 | 18 | 10 | 13 | 18 | 18 | 5 | |
| | | | | | | | | | | | | | |
| | 1400' | Average | (Median) 23 | 22 | 1 | 0 | 10 | 11.4 | 0.8 | 9 | 7.9 | 92 | |
| | | Maximum | 460 | 26 | 8 | 0.02 | 24 | 14.5 | 2.4 | 29 | 8.4 | 96 | |
| | | Minimum | < 3.0 | 18 | 0 | 0 | 0 | 6.0 | 0.2 | 1 | 7.5 | 88 | |
| | | No. of Samples | 33 | 13 | 26 | 21 | 26 | 20 | 22 | 26 | 24 | 13 | |
| | | | | | | | | | | | | | |
| | 1800' | Average | (Median) 3 | 19 | 2 | 0.01 | 7 | 13.5 | 0.5 | 13 | 7.8 | 95 | |
| | | Maximum | 430 | 20 | 18 | 0.06 | 23 | 14.7 | 0.8 | 25 | 8.5 | 96 | |
| | | Minimum | < 3.0 | 18 | 0 | 0 | 0 | 8.7 | 0.1 | 1 | 7.5 | 92 | |
| | | No. of Samples | 26 | 5 | 18 | 17 | 18 | 11 | 13 | 18 | 18 | 5 | |
| | 1700' | | EAST SHORE OF GRAND ISLAND | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| N1To-26.4 Tonawanda Creek at Delaware Ave. Bridge, Tonawanda, N.Y. | | Average | (Median) 15,000 | 20 | 56 | 0.19 | 8 | 9.9 | 3.9 | 17 | 7.6 | 100 | |
| | | Maximum | 240,000 | 30 | 400 | 0.44 | 25 | 13.7 | 9.9 | 36 | 8.3 | 126 | |
| | | Minimum | 2,300 | 9 | 0 | 0 | 0 | 4 | 1.3 | 6 | 7.3 | 79 | |
| | | No. of Samples | - 40 | 32 | 32 | 32 | 32 | 32 | 31 | 32 | 31 | 32 | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| N1-26.2 A range across the East Channel near the City of Tonawanda water intake | 0' | | UNITED STATES SHORE | | | | | | | | | | |
| | 200' | Average | (Median) 10,150 | 22 | 14 | 0.03 | 16 | 8.9 | 1.1 | 8 | 7.9 | 93 | |
| | | Maximum | 46,000 | 30 | 40 | 0.10 | 24 | 12.0 | 2.3 | 35 | 8.3 | 96 | |
| | | Minimum | 430 | 18 | 0 | 0 | 2 | 7.3 | 0.3 | 1 | 7.5 | 88 | |
| | | No. of Samples | 20 | 15 | 20 | 15 | 20 | 18 | 19 | 20 | 18 | 15 | |
| | | | | | | | | | | | | | |

## Table 18 - SUMMARY OF AVERAGE ANALYTICAL RESULTS - UPPER NIAGARA RIVER (Cont'd)

| Sampling Range and Mileage Index | Distance from East Shore | | Coliforms M.P.N. per 100ml. | Chlorides ppm | Phenols ppb | Ammonia as $N_2$ ppm | Temp. °C | D.O. ppm | B.O.D. 5 Day ppm | Turbidity ppm | pH | Alkalinity ppm | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | |
| N1-26.2 (Cont'd) | 500' | Average | (Median)<br>3,500 | 19 | [illegible] | 0.02 | 13 | 9.8 | 1.0 | 10 | 8.0 | 94 | |
| | | Maximum | 46,000 | 22 | 10 | 0.06 | 24 | 12.1 | 1.7 | 32 | 8.4 | 95 | |
| | | Minimum | 110 | 17 | 0 | 0 | 3 | 7.5 | 0.4 | 1 | 7.6 | 92 | |
| | | No. of Samples | 20 | 6 | 20 | 8 | 11 | 9 | 10 | 11 | 11 | 6 | |
| | | | | | | | | | | | | | |
| | 800' | Average | (Median)<br>2,100 | 19 | 0 | 0.01 | 13 | 9.9 | 0.8 | 10 | 8.0 | 95 | |
| | | Maximum | 15,000 | 20 | 3 | 0.04 | 24 | 12.2 | 1.8 | 29 | 8.4 | 96 | |
| | | Minimum | 36 | 16 | 0 | 0 | 2 | 7.1 | 0.1 | 1 | 7.5 | 94 | |
| | | No. of Samples | 11 | 6 | 11 | 9 | 11 | 9 | 10 | 11 | 11 | 6 | |
| | | | | | | | | | | | | | |
| | 1100' | Average | (Median)<br>250 | 21 | 0 | 0 | 16 | 9.4 | 0.8 | 6 | 8.0 | 93 | |
| | | Maximum | > 24,000 | 24 | 3 | 0.01 | 24 | 12.1 | 2.1 | 27 | 8.5 | 96 | |
| | | Minimum | 9.1 | 17 | 0 | 0 | 3 | 7.8 | 0.1 | 1 | 7.3 | 88 | |
| | | No. of Samples | 20 | 15 | 20 | 15 | 20 | 17 | 18 | 20 | 18 | 15 | |
| | | | | | | | | | | | | | |
| | 1300' | Average | (Median)<br>93 | 20 | 0 | 0.01 | 13 | 8.5 | 0.4 | 7 | 8.0 | 95 | |
| | | Maximum | > 1,500 | 21 | 3 | 0.04 | 24 | 8.8 | 0.7 | 21 | 8.5 | 96 | |
| | | Minimum | 9.1 | 19 | 0 | 0 | 3 | 8.0 | 0.2 | 1 | 7.7 | 94 | |
| | | No. of Samples | 19 | 5 | 19 | 8 | 10 | 4 | 5 | 10 | 10 | 5 | |
| | 1500' | | WATER INTAKE - CITY OF TONAWANDA, N.Y. | | | | | | | | | | |
| | 1500' | Average | (Median)<br>43 | 19 | 1 | 0 | 13 | 8.5 | 0.3 | 8 | 8.0 | 95 | |
| | | Maximum | 150 | 21 | 4 | 0 | 24 | 8.7 | 0.5 | 21 | 8.5 | 96 | |
| | | Minimum | < 3.6 | 17 | 0 | 0 | 3 | 8.0 | 0.2 | 1 | 7.4 | 94 | |
| | | No. of Samples | 11 | 6 | 11 | 9 | 11 | 4 | 5 | 11 | 11 | 6 | |
| | | | | | | | | | | | | | |
| | 1800' | Average | (Median)<br>43 | 21 | 1 | 0 | 16 | 8.6 | 0.7 | 5 | 8.0 | 92 | |
| | | Maximum | 460 | 24 | 10 | 0.06 | 24 | 10.1 | 1.4 | 18 | 8.5 | 96 | |
| | | Minimum | < 3.0 | 17 | 0 | 0 | 3 | 8.0 | 0.2 | 1 | 7.5 | 90 | |
| | | No. of Samples | 20 | 15 | 20 | 15 | 20 | 13 | 14 | 20 | 18 | 15 | |
| | 2000' | | EAST SHORE OF GRAND ISLAND | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| N1Et-26.8 Ellicott Creek at Fremont St. Bridge, City of Tonawanda, N.Y. | | Average | (Median)<br>93,000 | 22 | 9 | 0.76 | 8 | 8.1 | 4.3 | 15 | 7.5 | 126 | |
| | | Maximum | 460,000 | 44 | 100 | 2.8 | 25 | 12.6 | 10.5 | 34 | 8.2 | 171 | |
| | | Minimum | 2,300 | 9 | 0 | 0.16 | 0 | 0.9 | 1.6 | 4 | 7.1 | 93 | |
| | | No. of Samples | 41 | 33 | 33 | 32 | 33 | 32 | 32 | 32 | 32 | 33 | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| N1TM-27.2 Two Mile Creek at River Road Bridge, 0.5 miles south of City of Tonawanda N.Y. | | Average | (Median)<br>4,300 | 61 | 12 | 0.35 | 5 | 8.4 | 7.0 | 21 | 7.6 | 142 | |
| | | Maximum | 460,000 | 190 | 60 | 0.90 | 17 | 11.9 | 17.3 | 46 | 8.7 | 209 | |
| | | Minimum | 360 | 16 | 0 | 0.03 | 0 | 0.6 | 1.9 | 6 | 7.3 | 80 | |
| | | No. of Samples | 36 | 28 | 28 | 27 | 28 | 27 | 27 | 28 | 27 | 28 | |
| | | | | | | | | | | | | | |

Table 18 - SUMMARY OF AVERAGE ANALYTICAL RESULTS - UPPER NIAGARA RIVER

(Cont'd)

| Sampling Range and Mileage Index | Distance from East Shore | | Coliforms M.P.N. per 100ml. | Chlorides ppm | Phenols ppb | Ammonia as $N_2$ ppm | Temp. °C | D.O. ppm | B.O.D. 5 Day ppm | Turbidity ppm | pH | Alkalinity ppm | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ni-23.3 A range across the East Channel below the City of North Tonawanda, on a line between buoy ranges 11 and 12 | 0' | | UNITED STATES SHORE | | | | | | | | | | |
| | 100' | Average | (Median) 4,300 | 23 | 140 | 0.14 | 4 | 10.8 | 2.3 | 17 | 7.6 | 94 | |
| | | Maximum | 24,000 | 24 | 225 | 0.18 | 5 | 11.4 | 2.9 | 27 | 7.6 | 96 | |
| | | Minimum | 4,300 | 21 | 66 | 0.12 | 2 | 10.3 | 1.6 | 8 | 7.5 | 92 | |
| | | No. of Samples | 4 | 2 | 4 | 4 | 4 | 3 | 3 | 4 | 4 | 2 | |
| | | | | | | | | | | | | | |
| | 300' | Average | (Median) 3,300 | 21 | 20 | 0.08 | 4 | 11.2 | 1.8 | 16 | 7.7 | 95 | |
| | | Maximum | 7,500 | 21 | 30 | 0.12 | 5 | 11.6 | 2.1 | 37 | 7.8 | 95 | |
| | | Minimum | 930 | 20 | 10 | 0.06 | 2 | 11.0 | 1.6 | 6 | 7.5 | 95 | |
| | | No. of Samples | 4 | 2 | 4 | 4 | 4 | 3 | 3 | 4 | 4 | 2 | |
| | | | | | | | | | | | | | |
| | 600' | Average | (Median) 1,900 | 21 | 6 | 0.04 | 4 | 11.5 | 1.1 | 14 | 7.7 | 97 | |
| | | Maximum | 2,300 | 22 | 10 | 0.06 | 5 | 11.7 | 1.7 | 24 | 7.9 | 97 | |
| | | Minimum | 1,500 | 19 | Trace | 0.01 | 2 | 11.3 | 0.8 | 6 | 7.5 | 96 | |
| | | No. of Samples | 4 | 2 | 4 | 4 | 4 | 3 | 3 | 4 | 4 | 2 | |
| | | | | | | | | | | | | | |
| | 1000' | Average | (Median) 590 | 20 | 2 | 0.04 | 4 | 11.5 | 0.9 | 13 | 7.7 | 96 | |
| | | Maximum | 2,300 | 20 | 6 | 0.06 | 5 | 11.8 | 1.3 | 24 | 7.9 | 96 | |
| | | Minimum | 230 | 19 | 0 | 0 | 2 | 11.3 | 0.6 | 5 | 7.5 | 96 | |
| | | No. of Samples | 4 | 2 | 4 | 4 | 4 | 3 | 3 | 4 | 4 | 2 | |
| | | | | | | | | | | | | | |
| | 1500' | Average | (Median) 43 | 19 | Trace | 0 | 4 | | | 12 | 7.7 | 97 | |
| | | Maximum | 430 | 19 | Trace | 0 | 5 | | | 22 | 7.8 | 97 | |
| | | Minimum | 39 | 19 | 0 | 0 | 2 | | | 6 | 7.5 | 96 | |
| | | No. of Samples | 4 | 2 | 4 | 4 | 4 | | | 4 | 4 | 2 | |
| | | | | | | | | | | | | | |
| | 2000' | Average | (Median) 38 | 20 | 0 | 0 | 4 | | | 10 | 7.7 | 96 | |
| | | Maximum | 230 | 20 | Trace | 0 | 5 | | | 19 | 7.8 | 97 | |
| | | Minimum | 21 | 19 | 0 | 0 | 2 | | | 4 | 7.5 | 95 | |
| | | No. of Samples | 4 | 2 | 4 | 4 | 4 | | | 4 | 4 | 2 | |
| | | | | | | | | | | | | | |
| | 2400' | Average | (Median) 68 | 20 | Trace | 0 | 4 | | | 11 | 7.7 | 96 | |
| | | Maximum | 93 | 20 | Trace | 0 | 5 | | | 19 | 7.9 | 96 | |
| | | Minimum | 9.1 | 19 | 0 | 0 | 2 | | | 5 | 7.5 | 95 | |
| | | No. of Samples | 4 | 2 | 4 | 4 | 4 | | | 4 | 4 | 2 | |
| | 2700' | | EAST SHORE OF GRAND ISLAND | | | | | | | | | | |
| | | | | | | | | | | | | | |
| NiCa-21.0 Cayuga Creek at 88th Street Bridge, Niagara Falls, N.Y. | | | | | | | | | | | | | |
| | | Average | (Median) 23,000 | 22 | 24 | 0.27 | 9 | 8.0 | 3.9 | 22 | 7.6 | 111 | |
| | | Maximum | 150,000 | 33 | 140 | 0.72 | 25 | 13.1 | 8.9 | 86 | 8.1 | 155 | |
| | | Minimum | 4,300 | 8 | 0 | 0 | 0 | 3.8 | 2.1 | 4 | 7.3 | 57 | |
| | | No. of Samples | 35 | 27 | 27 | 26 | 27 | 25 | 26 | 27 | 27 | 27 | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |

Table 18 - SUMMARY OF AVERAGE ANALYTICAL RESULTS - UPPER NIAGARA RIVER (Cont'd)

| Sampling Range and Mileage Index | Distance from East Shore | | Coliforms M.P.N. per 100ml. | Chlorides ppm | Phenols ppb | Ammonia as $N_2$ ppm | Temp. °C | D.O. ppm | B.O.D. 5 Day ppm | Turbidity ppm | pH | Alkalinity ppm | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M1-19.3 A range across the East Channel at the North Grand Island Bridge | 0' | | UNITED STATES SHORE | | | | | | | | | | |
| | 300' | Average | (Median) 9,300 | 25 | 53 | 0.08 | 11 | 10.1 | 1.8 | 12 | 7.8 | 91 | |
| | | Maximum | 110,000 | 28 | 260 | 0.24 | 24 | 13.9 | 3.9 | 36 | 8.3 | 94 | |
| | | Minimum | 430 | 20 | 0 | 0 | 0 | 6.0 | 0.3 | 1 | 7.3 | 82 | |
| | | No. of Samples | 43 | 14 | 32 | 27 | 32 | 31 | 32 | 32 | 30 | 13 | |
| | 600' | Average | (Median) 3,900 | 22 | 46 | 0.07 | 8 | 11.4 | 1.6 | 14 | 7.7 | 92 | |
| | | Maximum | 24,000 | 23 | 240 | 0.22 | 24 | 14.3 | 3.3 | 28 | 8.3 | 94 | |
| | | Minimum | 230 | 22 | 3 | 0 | 0 | 7.1 | 0.9 | 1 | 7.4 | 90 | |
| | | No. of Samples | 35 | 5 | 24 | 22 | 24 | 22 | 24 | 24 | 24 | 4 | |
| | 900' | Average | (Median) 4,100 | 21 | 12 | 0.04 | 8 | 11.7 | 1.4 | 12 | 7.9 | 92 | |
| | | Maximum | 43,000 | 23 | 65 | 0.12 | 24 | 14.5 | 2.8 | 28 | 8.3 | 94 | |
| | | Minimum | 230 | 20 | 0 | 0 | 0 | 7.6 | 0.2 | 1 | 7.3 | 88 | |
| | | No. of Samples | 44 | 5 | 33 | 22 | 24 | 22 | 24 | 24 | 24 | 4 | |
| | 1400' | Average | (Median) 2,300 | 20 | 7 | 0.02 | 8 | 11.9 | 1.1 | 11 | 7.8 | 91 | |
| | | Maximum | > 11,000 | 22 | 35 | 0.06 | 24 | 14.4 | 2.8 | 21 | 8.4 | 94 | |
| | | Minimum | 23 | 19 | 0 | 0 | 0 | 8.1 | 0.5 | 1 | 7.3 | 84 | |
| | | No. of Samples | 35 | 5 | 24 | 22 | 24 | 20 | 22 | 24 | 24 | 4 | |
| | 1900' | Average | (Median) 930 | 22 | 2 | 0.01 | 11 | 11.3 | 0.9 | 9 | 7.9 | 92 | |
| | | Maximum | 24,000 | 27 | 10 | 0.03 | 24 | 14.5 | 2.5 | 22 | 8.4 | 96 | |
| | | Minimum | 23 | 18 | 0 | 0 | 0 | 8.1 | 0 | 1 | 7.4 | 88 | |
| | | No. of Samples | 44 | 14 | 33 | 28 | 33 | 25 | 26 | 33 | 31 | 13 | |
| | 2500' | Average | (Median) 230 | 20 | 2 | 0 | 8 | 13.1 | 0.6 | 10 | 7.9 | 96 | |
| | | Maximum | > 1,100 | 20 | 6 | 0.01 | 24 | 14.5 | 2.1 | 22 | 8.5 | 102 | |
| | | Minimum | 15 | 18 | 0 | 0 | 0 | 9.2 | 0.2 | 1 | 7.5 | 92 | |
| | | No. of Samples | 33 | 5 | 23 | 22 | 23 | 14 | 16 | 23 | 23 | 4 | |
| | 3000' | Average | (Median) 75 | 21 | 1 | 0.01 | 8 | 13.3 | 0.6 | 10 | 7.9 | 95 | |
| | | Maximum | 4,600 | 24 | 6 | 0.06 | 24 | 14.5 | 1.3 | 19 | 8.5 | 98 | |
| | | Minimum | 3.6 | 18 | 0 | 0 | 0 | 9.1 | 0.1 | 1 | 7.5 | 92 | |
| | | No. of Samples | 42 | 5 | 32 | 21 | 23 | 15 | 16 | 23 | 23 | 4 | |
| | 3500' | Average | (Median) 43 | 21 | 52 | 0 | 11 | 11.5 | 1.0 | 8 | 7.9 | 92 | |
| | | Maximum | 1,100 | 24 | 1600 | 0.06 | 24 | 14.4 | > 7.2 | 25 | 8.5 | 104 | |
| | | Minimum | 9.1 | 17 | 0 | 0 | 0 | 7.9 | 0.1 | 1 | 7.5 | 88 | |
| | | No. of Samples | 43 | 14 | 32 | 25 | 32 | 24 | 24 | 32 | 30 | 13 | |
| | 3600' | | EAST SHORE OF GRAND ISLAND | | | | | | | | | | |

Table 18 - SUMMARY OF AVERAGE ANALYTICAL RESULTS - UPPER NIAGARA RIVER

(Cont'd)

| Sampling Range and Mileage Index | Distance from East Shore | | Coliforms M.P.N. per 100ml. | Chlorides ppm | Phenols ppb | Ammonia as $N_2$ ppm | Temp. °C | D.O. ppm | B.O.D. 5 Day ppm | Turbidity ppm | pH | Alkalinity ppm | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| N1-26.7 A range across the West Channel below Beaver Island State Park | 0' | | WEST SHORE OF GRAND ISLAND | | | | | | | | | | |
| | 300' | Average | (Median)<br>9.1 | 22 | 0 | 0 | 21 | 9.7 | 1.1 | 3 | 8.3 | 93 | |
| | | Maximum | 73 | 25 | 2 | 0 | 25 | 12.1 | 2.5 | 7 | 8.6 | 96 | |
| | | Minimum | < 3.0 | 18 | 0 | 0 | 12 | 8.6 | 0 | 1 | 7.9 | 90 | |
| | | No. of Samples | 18 | 11 | 17 | 8 | 13 | 8 | 8 | 13 | 13 | 10 | |
| | 400' | | INTERNATIONAL BOUNDARY | | | | | | | | | | |
| | 800' | Average | (Median)<br>23 | 21 | 0 | 0 | 12 | 9.3 | 1.1 | 3 | 8.2 | 93 | |
| | | Maximum | 75 | 25 | 3 | 0 | 25 | 10.9 | 4.3 | 7 | 8.5 | 96 | |
| | | Minimum | < 3.0 | 17 | 0 | 0 | 12 | 8.5 | 0.1 | 1 | 7.9 | 88 | |
| | | No. of Samples | 17 | 14 | 18 | 7 | 16 | 12 | 12 | 15 | 16 | 13 | |
| | | | | | | | | | | | | | |
| | 1400' | Average | (Median)<br>10 | 22 | 0 | 0 | 19 | 9.3 | 0.8 | 3 | 8.2 | 93 | |
| | | Maximum | 43 | 26 | 0 | 0.02 | 25 | 11.0 | 2.1 | 10 | 8.5 | 96 | |
| | | Minimum | < 3.0 | 18 | 0 | 0 | 12 | 8.2 | 0.3 | 1 | 7.9 | 88 | |
| | | No. of Samples | 18 | 14 | 18 | 8 | 16 | 12 | 12 | 15 | 16 | 13 | |
| | | | | | | | | | | | | | |
| | 1900' | Average | (Median)<br>445 | 22 | 0 | 0 | 21 | 9.2 | 0.9 | 2 | 8.3 | 92 | |
| | | Maximum | 2,400 | 26 | 3 | 0 | 25 | 10.9 | 2.1 | 7 | 8.5 | 95 | |
| | | Minimum | •11 | 18 | 0 | 0 | 12 | 8.2 | 0.1 | 1 | 7.9 | 88 | |
| | | No. of Samples | 18 | 11 | 17 | 8 | 12 | 9 | 9 | 13 | 13 | 10 | |
| | 2100' | | CANADIAN SHORE | | | | | | | | | | |
| | | | | | | | | | | | | | |
| N1B1-24.3 Black Creek at confluence with West Channel, Willoughby Township, Ontario | | | | | | | | | | | | | |
| | | Average | (Median)<br>2,400 | 18 | 1 | 0.36 | 4 | 10.7 | 2.1 | 74 | 7.5 | 61 | |
| | | Maximum | 2,400 | 45 | 5 | 0.36 | 6 | 11.9 | 3.3 | 150 | 7.9 | 96 | |
| | | Minimum | 1,700 | 5 | 0 | 0.36 | 1 | 9.0 | 1.1 | 38 | 7.2 | 26 | |
| | | No. of Samples | 4 | 4 | 4 | 1 | 3 | 4 | 4 | 4 | 4 | 4 | |
| | | | | | | | | | | | | | |
| N1-20.0 A range across the West Channel from the head of Navy Island to the Canadian shore | | | | | | | | | | | | | |
| | 0' | | WEST SHORE OF NAVY ISLAND | | | | | | | | | | |
| | 300' | Average | (Median)<br>23 | 22 | 4 | 0 | 18 | 9.6 | 0.8 | 2 | 8.2 | 92 | |
| | | Maximum | 43 | 25 | 60 | 0.01 | 25 | 12.0 | 1.3 | 5 | 8.4 | 94 | |
| | | Minimum | < 3.0 | 19 | 0 | 0 | 8 | 8.0 | 0.2 | 1 | 7.7 | 90 | |
| | | No. of Samples | 16 | 7 | 16 | 9 | 11 | 7 | 6 | 11 | 11 | 7 | |
| | | | | | | | | | | | | | |
| | 800' | Average | (Median)<br>9.1 | 21 | 0 | 0 | 17 | 9.7 | 0.9 | 4 | 8.2 | 92 | |
| | | Maximum | 23 | 25 | 4 | Trace | 25 | 11.6 | 1.3 | 15 | 8.4 | 96 | |
| | | Minimum | < 3.0 | 18 | 0 | 0 | 8 | 8.1 | 0.5 | 1 | 7.7 | 90 | |
| | | No. of Samples | 16 | 10 | 16 | 8 | 14 | 10 | 9 | 13 | 14 | 10 | |
| | | | | | | | | | | | | | |
| | 1400' | Average | (Median)<br>23 | 21 | 1 | 0 | 17 | 9.8 | 0.6 | 4 | 8.1 | 93 | |
| | | Maximum | 150 | 25 | 5 | 0 | 25 | 11.7 | 1.1 | 12 | 8.4 | 98 | |
| | | Minimum | < 3.0 | 19 | 0 | 0 | 8 | 8.0 | 0.3 | 1 | 7.7 | 90 | |
| | | No. of Samples | 16 | 9 | 16 | 8 | 13 | 9 | 8 | 13 | 13 | 9 | |

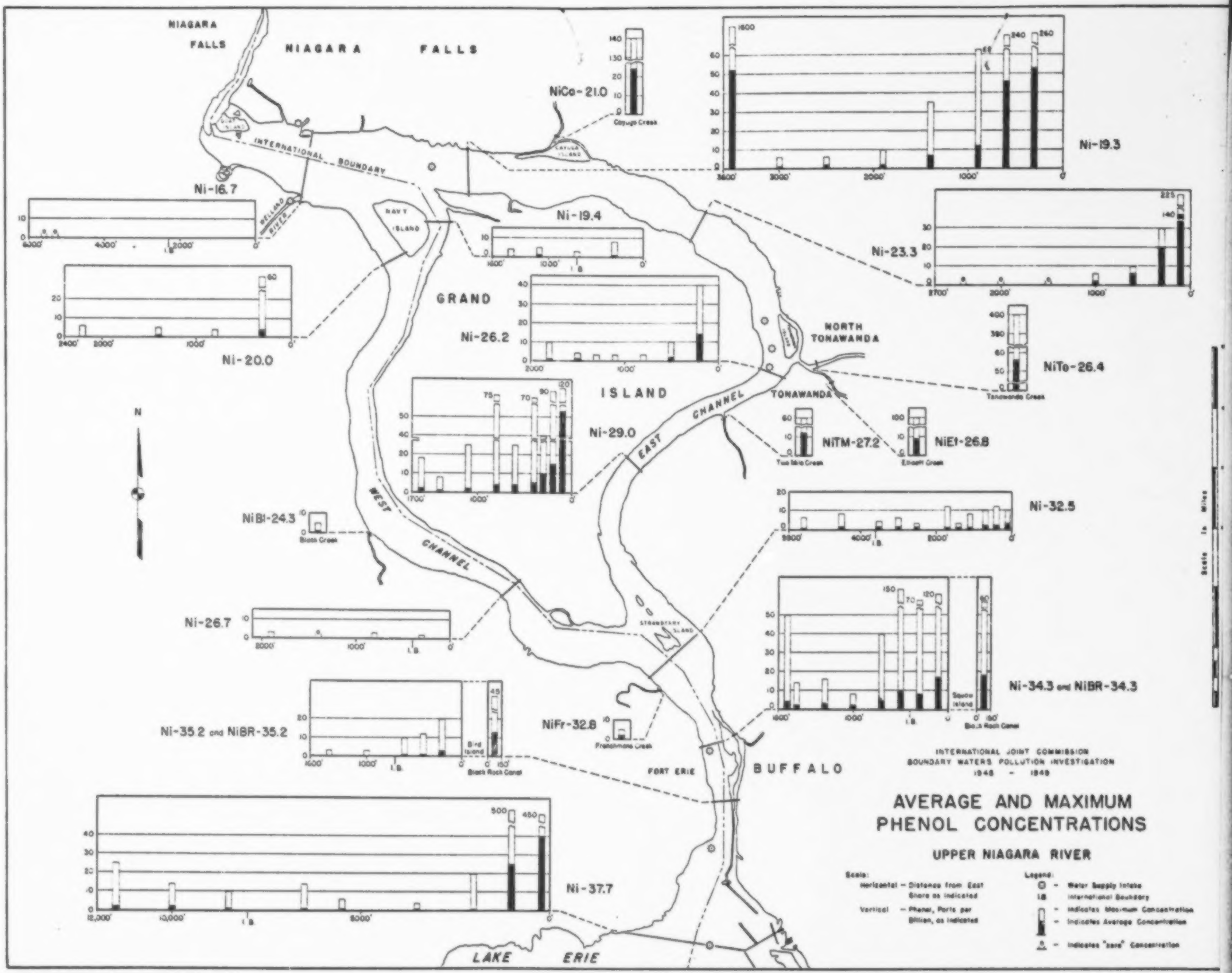
## Table 18 - SUMMARY OF AVERAGE ANALYTICAL RESULTS - UPPER NIAGARA RIVER (Cont'd)

| Sampling Range and Mileage Index | Distance from East Shore | | Coliforms M.P.N. per 100ml. | Chlorides ppm | Phenols ppb | Ammonia as $N_2$ ppm | Temp. °C | D.O. ppm | B.O.D. 5 Day ppm | Turbidity ppm | pH | Alkalinity ppm | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ni-20.0 (Cont'd) | 2200' | Average | (Median) 190 | 22 | 0 | 0 | 18 | 9.5 | 0.8 | 3 | 8.2 | 92 | |
| | | Maximum | 1,100 | 24 | 6 | Trace | 25 | 11.7 | 1.6 | 9 | 8.4 | 95 | |
| | | Minimum | 21 | 18 | 0 | 0 | 8 | 7.8 | 0.5 | 1 | 7.7 | 88 | |
| | | No. of Samples | 16 | 7 | 15 | 9 | 11 | 7 | 6 | 11 | 11 | 7 | |
| | 2400' | | CANADIAN SHORE | | | | | | | | | | |
| | | | | | | | | | | | | | |
| Ni-19.4 A range across the International Branch of the West Channel between Grand Island and Navy Island | | | | | | | | | | | | | |
| | 0' | | WEST SHORE OF GRAND ISLAND | | | | | | | | | | |
| | 300' | | | | | | | | | | | | |
| | | Average | (Median) 23 | 22 | 1 | 0 | 18 | 9.6 | 1.8 | 3 | 8.2 | 92 | |
| | | Maximum | 93 | 24 | 8 | Trace | 25 | 11.6 | 5.2 | 7 | 8.4 | 94 | |
| | | Minimum | < 3.0 | 19 | 0 | 0 | 8 | 8.0 | 0.3 | 1 | 7.5 | 90 | |
| | | No. of Samples | 18 | 7 | 17 | 10 | 12 | 7 | 7 | 12 | 12 | 7 | |
| | 700' | | INTERNATIONAL BOUNDARY | | | | | | | | | | |
| | 700' | Average | (Median) 9.1 | 22 | 0 | 0 | 17 | 9.8 | 0.9 | 3 | 8.2 | 90 | |
| | | Maximum | 93 | 26 | 3 | 0 | 25 | 11.6 | 2.7 | 10 | 8.4 | 96 | |
| | | Minimum | < 3.0 | 18 | 0 | 0 | 8 | 8.0 | 0.3 | 1 | 7.7 | 68 | |
| | | No. of Samples | 18 | 9 | 17 | 9 | 14 | 9 | 9 | 14 | 14 | 9 | |
| | 1100' | | | | | | | | | | | | |
| | | Average | (Median) 23 | 22 | 1 | 0 | 17 | 9.6 | 1.1 | 3 | 8.1 | 91 | |
| | | Maximum | 93 | 27 | 5 | Trace | 25 | 11.6 | 2.3 | 10 | 8.4 | 96 | |
| | | Minimum | < 3.0 | 19 | 0 | 0 | 8 | 8.1 | 0.2 | 1 | 7.6 | 81 | |
| | | No. of Samples | 18 | 10 | 17 | 9 | 15 | 10 | 10 | 14 | 15 | 10 | |
| | 1400' | | | | | | | | | | | | |
| | | Average | (Median) 19 | 22 | 0 | 0 | 18 | 9.7 | 0.8 | 3 | 8.2 | 92 | |
| | | Maximum | 230 | 24 | 4 | Trace | 25 | 11.7 | 1.4 | 7 | 8.6 | 95 | |
| | | Minimum | < 3.0 | 19 | 0 | 0 | 8 | 8.3 | 0.4 | 1 | 7.5 | 88 | |
| | | No. of Samples | 18 | 7 | 16 | 10 | 12 | 6 | 7 | 12 | 12 | 7 | |
| | 1600' | | EAST SHORE OF NAVY ISLAND | | | | | | | | | | |
| | | | | | | | | | | | | | |
| Ni-16.7 A range across the upper Niagara River from a point upstream from Grass Island to the mouth of the Welland River | | | | | | | | | | | | | |
| | 0' | | UNITED STATES SHORE | | | | | | | | | | |
| | 2300' | | INTERNATIONAL BOUNDARY | | | | | | | | | | |
| | 5300' Outside Mouth | Average | (Median) 120 | | 0 | | | | | | | | |
| | | Maximum | 4,600 | | 0 | | | | | | | | |
| | | Minimum | 3.6 | | 0 | | | | | | | | |
| | | No. of Samples | 4 | | 4 | | | | | | | | |
| | 5600' Inside Mouth | | | | | | | | | | | | |
| | | Average | (Median) 1,100 | 19 | 0 | 0.48 | 12 | 10.9 | 0.9 | 17 | 7.9 | 90 | |
| | | Maximum | > 15,000 | 23 | Trace | 0.48 | 12 | 11.4 | 2.8 | 25 | 8.0 | 94 | |
| | | Minimum | 460 | 17 | 0 | 0.48 | 11 | 10.5 | 0 | 8 | 7.6 | 88 | |
| | | No. of Samples | 5 | 5 | 4 | 1 | 2 | 5 | 5 | 5 | 5 | 5 | |
| | 6000' | | CANADIAN SHORE | | | | | | | | | | |
| | | | | | | | | | | | | | |

## Table 18 - SUMMARY OF AVERAGE ANALYTICAL RESULTS - UPPER NIAGARA RIVER
(Cont'd)

| Sampling Range and Location | Mileage Index | | Coliforms M.P.N. per 100ml. | Chlorides ppm | Phenols ppb | Ammonia as $N_2$ ppm | Temp. °C | D.O. ppm | B.O.D. 5 Day ppm | Turbidity ppm | pH | Alkalinity ppm | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | UPPER | NIAGARA | | RIVER | | TRIBUTARIES | | | | | |
| Buffalo River at mouth, Buffalo, New York | NiBu -37.6 | Average | (Median) 33,000 | 43 | 1860 | 0.64 | 8 | 4.3 | 7.4 | 24 | 7.2 | 85 | |
| | | Maximum | 43,000 | 57 | 3600 | 0.64 | 13 | 4.3 | 7.4 | 25 | 7.3 | 94 | |
| | | Minimum | 23,000 | 29 | 120 | 0.64 | 2 | 4.3 | 7.4 | 24 | 7.0 | 75 | |
| | | No. of Samples | 2 | 2 | 2 | 1 | 2 | 1 | 1 | 2 | 2 | 2 | |
| Buffalo River at Michigan Avenue Bridge | NiBu -38.7 | Average | (Median) 9,300 | 46 | 469 | 0.71 | 8 | 7.3 | 14.4 | 52 | 6.9 | 66 | |
| | | Maximum | 240,000 | 181 | 1400 | 1.50 | 13 | 13.2 | 31.5 | 193 | 7.4 | 95 | |
| | | Minimum | 910 | 8 | 35 | 0.26 | 0 | 0 | 6.2 | 18 | 5.9 | 36 | |
| | | No. of Samples | 36 | 23 | 25 | 25 | 25 | 25 | 25 | 25 | 24 | 23 | |
| Buffalo River at Ohio Street Bridge | NiBu -39.4 | Average | (Median) 15,000 | 54 | 596 | 0.87 | 7 | 7.3 | 15.0 | 43 | 6.7 | 66 | |
| | | Maximum | 240,000 | 265 | 1750 | 4.60 | 20 | 13.1 | 44 | 146 | 7.1 | 92 | |
| | | Minimum | 2,300 | 9 | 14 | 0.24 | 0 | 0 | 4.0 | 13 | 6.0 | 34 | |
| | | No. of Samples | 32 | 20 | 22 | 22 | 22 | 22 | 22 | 22 | 21 | 20 | |
| Buffalo River at New York Central Railroad Bridge | NiBu -41.3 | Average | (Median) 4,100 | 33 | 800 | 0.64 | 11 | 8.5 | 12.7 | 31 | 6.8 | 51 | |
| | | Maximum | 4,300 | 42 | 800 | 0.76 | 11 | 8.6 | 15.3 | 41 | 7.1 | 70 | |
| | | Minimum | 3,900 | 24 | 800 | 0.52 | 11 | 8.4 | 10.0 | 21 | 6.5 | 31 | |
| | | No. of Samples | 2 | 2 | 1 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | |
| Buffalo River at South Park Ave. Bridge | NiBu -42.4 | Average | (Median) 19,000 | 35 | 179 | 0.51 | 7 | 9.5 | 10.7 | 25 | 7.0 | 75 | |
| | | Maximum | 240,000 | 191 | 1125 | 1.8 | 25 | 13.9 | 31.5 | 64 | 7.9 | 101 | |
| | | Minimum | 2,300 | 2 | 14 | 0.06 | 0 | 0 | 2.2 | 11 | 5.7 | 11 | |
| | | No. of Samples | 30 | 18 | 21 | 21 | 21 | 21 | 21 | 21 | 20 | 18 | |
| Buffalo River below Socony Vacuum Oil Co. outfalls and above National Aniline Division outfalls | NiBu -42.9 | Average | (Median) 6,800 | 10.5 | 275 | 0.20 | 9 | 10.3 | 5.7 | 17 | 7.7 | 81 | |
| | | Maximum | 9,300 | 11 | 275 | 0.24 | 9 | 10.4 | 7.1 | 24 | 7.7 | 81 | |
| | | Minimum | 4,300 | 10 | 275 | 0.16 | 9 | 10.2 | 4.3 | 9 | 7.7 | 81 | |
| | | No. of Samples | 2 | 2 | 1 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | |
| Buffalo River at Bailey Avenue Bridge | NiBu -43.4 | Average | (Median) 22,000 | 16 | 39 | 0.24 | 5 | 10.5 | 6.1 | 25 | 7.4 | 96 | |
| | | Maximum | 93,000 | 77 | 450 | 0.90 | 23 | 14.0 | 28.2 | 58 | 7.9 | 126 | |
| | | Minimum | 4,300 | 5 | 0 | 0.03 | 0 | 0 | 0.9 | 4 | 6.5 | 59 | |
| | | No. of Samples | 28 | 20 | 21 | 20 | 21 | 20 | 20 | 21 | 20 | 20 | |
| Casenovia Creek at Bailey Ave. Bridge, Buffalo, N.Y. | NiBuCa -43.4 | Average | (Median) 9,300 | 15 | 35 | 0.21 | 6 | 10.8 | 5.3 | 25 | 7.4 | 73 | |
| | | Maximum | 1,100,000 | 93 | 350 | 1.4 | 22 | 14.4 | 18.6 | 58 | 7.9 | 113 | |
| | | Minimum | 2,300 | 3 | 0 | 0 | 0 | 0 | 0.6 | 6 | 6.8 | 51 | |
| | | No. of Samples | 26 | 17 | 18 | 17 | 18 | 17 | 17 | 18 | 18 | 17 | |

140-B


NIAGARA FALLS
NIAGARA FALLS
INTERNATIONAL BOUNDARY
WELLAND RIVER
NAVY ISLAND
CAYUGA ISLAND
GRAND ISLAND
NORTH TONAWANDA
TONAWANDA
EAST CHANNEL
WEST CHANNEL
STRAWBERRY ISLAND
FORT ERIE
BUFFALO
LAKE ERIE
N
Scale in Miles
Ni-16.7
Ni-19.3
Ni-19.4
NiCa-21.0
Cayuga Creek
Ni-20.0
Ni-23.3
Ni-26.2
NiTo-26.4
Tonawanda Creek
Ni-29.0
NiTM-27.2
Two Mile Creek
NiE1-26.8
Ellicott Creek
NiBl-24.3
Black Creek
Ni-32.5
Ni-26.7
Ni-34.3 and NiBR-34.3
Squaw Island
Black Rock Canal
NiFr-32.8
Frenchmans Creek
Ni-35.2 and NiBR-35.2
Bird Island
Black Rock Canal
Ni-37.7
1600
240
260
225
140
60
75
70
90
120
150
70
120
60
45
500
450
I.B.

INTERNATIONAL JOINT COMMISSION
BOUNDARY WATERS POLLUTION INVESTIGATION
1946 - 1949

AVERAGE AND MAXIMUM
PHENOL CONCENTRATIONS

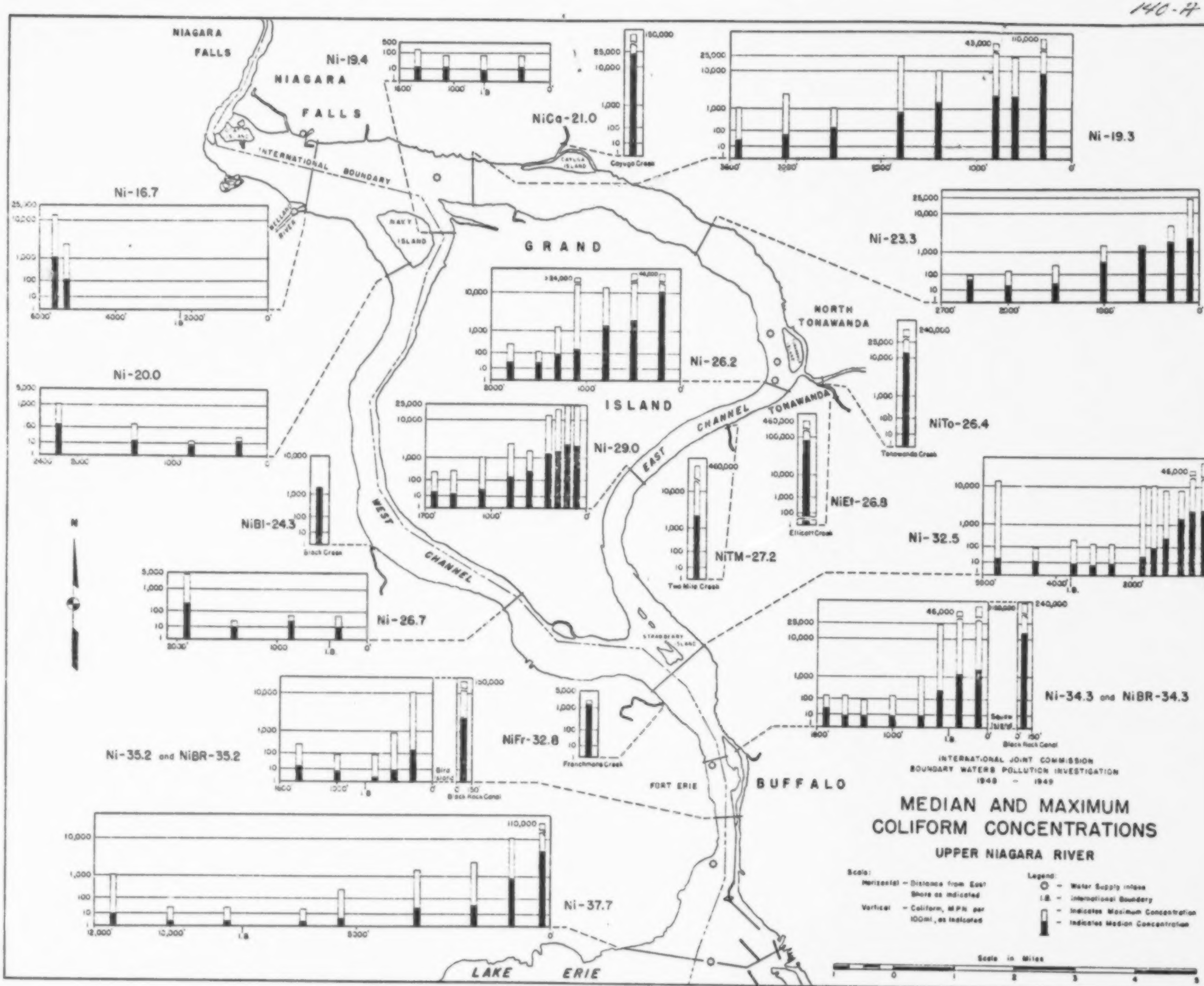
UPPER NIAGARA RIVER

Scale:
Horizontal – Distance from East Shore as Indicated
Vertical – Phenol, Parts per Billion, as Indicated

Legend:
○ – Water Supply Intake
I.B. – International Boundary
▯ – Indicates Maximum Concentration
▮ – Indicates Average Concentration
△ – Indicates "zero" Concentration

FIGURE 6

140-7


NIAGARA FALLS
NIAGARA FALLS
INTERNATIONAL BOUNDARY
WELLAND RIVER
NAVY ISLAND
GRAND ISLAND
NORTH TONAWANDA
TONAWANDA
EAST CHANNEL
WEST CHANNEL
STRAWBERRY ISLAND
FORT ERIE
BUFFALO
LAKE ERIE
CAYUGA ISLAND
Ni-19.4
NiCa-21.0
Cayuga Creek
Ni-19.3
Ni-16.7
Ni-23.3
Ni-26.2
Ni-20.0
Ni-29.0
NiTo-26.4
Tonawanda Creek
NiBI-24.3
Black Creek
NiEl-26.8
Ellicott Creek
NiTM-27.2
Two Mile Creek
Ni-32.5
Ni-26.7
Ni-34.3 and NiBR-34.3
Squaw Island
Black Rock Canal
NiFr-32.8
Frenchmans Creek
Ni-35.2 and NiBR-35.2
Bird Island
Black Rock Canal
Ni-37.7
N
Scale in Miles
1 0 1 2 3 4 5

INTERNATIONAL JOINT COMMISSION
BOUNDARY WATERS POLLUTION INVESTIGATION
1948 – 1949

MEDIAN AND MAXIMUM
COLIFORM CONCENTRATIONS
UPPER NIAGARA RIVER

Scale:
Horizontal – Distance from East Shore as indicated
Vertical – Coliform, M.P.N. per 100ml., as indicated

Legend:
○ – Water Supply intake
I.B. – International Boundary
▯ – Indicates Maximum Concentration
▮ – Indicates Median Concentration

FIGURE 5

Lower Niagara River

The Niagara Falls, the lower rapids, the Whirlpool, and the Whirlpool Rapids combine to give thorough mixing of the waters in the lower Niagara River. The polluted water, from the East Channel in the upper river, is intermixed with the cleaner water from the West Channel. The bacteriological and chemical data, summarized in table 19, confirm this mixing and show that the pollution in the lower river was evenly dispersed throughout its cross-sectional area. Figures 7 and 8 show graphically the median and maximum coliform, and average and maximum phenol results, respectively.

The median M.P.N. values per 100 ml., at the two ranges just below the Falls at the Rainbow Bridge (Ni - 14.7) and the Whirlpool Rapids Bridge (Ni - 12.7), varied from 430 to 1,900 with a maximum of 11,000 M.P.N. per 100 ml. found on Range Ni - 12.7. The median values for samples taken on ranges from the Lewiston Bridge (Ni - 8.0) to the outlet of the river varied only slightly from a value of 2,400 M.P.N. per 100 ml. The maximum M.P.N. varied from 9,300 to 46,000 on these same ranges. The discharge of raw sewage from the City of Niagara Falls, Ontario, the discharge from the Niagara Falls, New York, sewage treatment plant, and the discharge from the Hydro Electric Power Commission's power canal at Queenston combine to account for the increase in median and maximum coliform values between the Whirlpool Rapids and Lewiston Bridges.

Average values of phenol concentrations on the Ranges Ni - 14.1 and 12.7 were found to be several times higher than the average values found on the four ranges below the Lewiston Bridge. The average values at the upstream ranges varied from 5 to 17 p.p.b., in comparison to average values of 0 to 2 p.p.b. being recorded below Range Ni - 8.0. A maximum value of 80 p.p.b. was found on Range Ni - 12.7, with 70 p.p.b. noted on Range Ni - 6.8.

Other chemical substances showed no significant changes in passing through the lower river. Dissolved oxygen content was near saturation, and average B.O.D. values were below 2.2 p.p.m.

## Table 19 - SUMMARY OF AVERAGE ANALYTICAL RESULTS - LOWER NIAGARA RIVER

| Sampling Range and Mileage index | Distance from East Shore | | Coliforms M.P.N. per 100ml | Chlorides ppm | Phenols ppb | Ammonia as $N_2$ ppm | Temp °C | D.O. ppm | B.O.D. 5 Day ppm | Turbidity ppm | pH | Alkalinity ppm | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ni-14.1 A range across the lower river at the Rainbow Bridge | 0' | | UNITED STATES SHORE | | | | | | | | | | |
| | 100' | Average | (Median) 430 | | 5 | 0.01 | 1 | 17.5 | 0.9 | 19 | 7.6 | | |
| | | Maximum | 1,500 | | 10 | 0.03 | 2 | 18.3 | 1.6 | 35 | 7.7 | | |
| | | Minimum | 36 | | Trace | 0 | 0 | 16.6 | 0.6 | 10 | 7.5 | | |
| | | No. of Samples | 6 | | 6 | 6 | 6 | 6 | 6 | 5 | 5 | | |
| | 400' | | INTERNATIONAL BOUNDARY | | | | | | | | | | |
| | 400' | Average | (Median) 930 | | 9 | 0.02 | 1 | 17.3 | 0.8 | 16 | 7.7 | | |
| | | Maximum | 4,300 | | 20 | 0.06 | 2 | 17.8 | 1.5 | 25 | 7.7 | | |
| | | Minimum | 230 | | Trace | 0 | 0 | 16.9 | 0.2 | 9 | 7.5 | | |
| | | No. of Samples | 6 | | 6 | 6 | 6 | 6 | 6 | 5 | 6 | | |
| | | | | | | | | | | | | | |
| | 700' | Average | (Median) 840 | | 10 | 0.01 | 1 | 17.1 | 1.0 | 18 | 7.7 | | |
| | | Maximum | 1,500 | | 18 | 0.03 | 2 | 17.6 | 2.3 | 31 | 7.7 | | |
| | | Minimum | 430 | | 6 | 0 | 0 | 16.7 | 0.4 | 12 | 7.6 | | |
| | | No. of Samples | 6 | | 6 | 6 | 6 | 6 | 6 | 5 | 6 | | |
| | 800' | | CANADIAN SHORE | | | | | | | | | | |
| | | | | | | | | | | | | | |
| Ni-12.7 A range across the river at the Whirlpool Rapids Bridge | 0' | | UNITED STATES SHORE | | | | | | | | | | |
| | 75' | Average | (Median) 930 | | 8 | 0.02 | 1 | 16.7 | 1.0 | 18 | 7.7 | | |
| | | Maximum | 9,300 | | 12 | 0.03 | 2 | 17.4 | 1.6 | 30 | 7.7 | | |
| | | Minimum | 150 | | 3 | 0 | 0 | 16.3 | 0.5 | 10 | 7.5 | | |
| | | No. of Samples | 8 | | 7 | 7 | 7 | 7 | 7 | 6 | 7 | | |
| | 150' | | INTERNATIONAL BOUNDARY | | | | | | | | | | |
| | 150' | Average | (Median) 1,615 | | 9 | 0.02 | 1 | 16.7 | 0.8 | 19 | 7.7 | | |
| | | Maximum | > 11,000 | | 18 | 0.06 | 2 | 17.3 | 1.1 | 29 | 7.7 | | |
| | | Minimum | 230 | | 3 | 0 | 0 | 16.2 | 0.5 | 11 | 7.5 | | |
| | | No. of Samples | 9 | | 7 | 7 | 7 | 6 | 7 | 6 | 7 | | |
| | | | | | | | | | | | | | |
| | 225' | Average | (Median) 1,900 | | 17 | 0.02 | 1 | 16.8 | 1.0 | 18 | 7.7 | | |
| | | Maximum | 9,300 | | 80 | 0.03 | 2 | 17.3 | 2.1 | 26 | 7.7 | | |
| | | Minimum | 230 | | 4 | 0 | 0 | 16.3 | 0.7 | 9 | 7.5 | | |
| | | No. of Samples | 8 | | 7 | 7 | 7 | 6 | 7 | 6 | 7 | | |
| | 300' | | CANADIAN SHORE | | | | | | | | | | |
| | | | | | | | | | | | | | |
| NiWt-11.4 Whitty's Creek at discharge to the Whirlpool, Stamford Township, Ontario | | | | | | | | | | | | | |
| | | Average | (Median) 24,000 | 34 | 0 | 1.02 | 17 | | 2.3 | 20 | 8.7 | 119 | |
| | | Maximum | >150,000 | 46 | 0 | 1.56 | 17 | | 3.9 | 35 | 9.1 | 152 | |
| | | Minimum | 2,400 | 24 | 0 | 0.48 | 16 | | 0.8 | 10 | 8.4 | 90 | |
| | | No. of Samples | 9 | 6 | 4 | 2 | 2 | | 5 | 6 | 6 | 6 | |
| | | | | | | | | | | | | | |

Table 19 - SUMMARY OF AVERAGE ANALYTICAL RESULTS - LOWER NIAGARA RIVER (Cont'd)

| Sampling Range and Mileage Index | Distance from East Shore | | Coliforms M.P.N. per 100ml. | Chlorides ppm | Phenols ppb | Ammonia as $N_2$ ppm | Temp. °C | D.O. ppm | B.O.D. 5 Day ppm | Turbidity ppm | pH | Alkalinity ppm | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| N1PC-9.0 Hydro Electric Power Commission's power canal at discharge to lower Niagara River at Queenston, Ontario | | Average | (Median)<br>2,000 | 19 | 0 | 0.26 | 5 | 12.6 | 1.5 | 20 | 7.9 | 91 | |
| | | Maximum | 11,000 | 25 | Trace | 0.48 | 12 | 14.2 | 4.1 | 50 | 8.1 | 100 | |
| | | Minimum | 400 | 15 | 0 | 0.04 | 0 | 10.3 | 0.2 | 6 | 7.9 | 78 | |
| | | No. of Samples | 18 | 18 | 15 | 2 | 14 | 16 | 13 | 17 | 17 | 18 | |
| | | | | | | | | | | | | | |
| N1-8.0 A range across the river at the Lewiston Bridge | | | | | | | | | | | | | |
| | 0' | | UNITED STATES SHORE | | | | | | | | | | |
| | 100' | Average | (Median)<br>2,400 | 20 | 1 | 0.02 | 15 | 11.9 | 1.6 | 7 | 8.0 | 93 | |
| | | Maximum | 46,000 | 25 | 16 | 0.44 | 23 | 17.6 | 4.8 | 30 | 8.5 | 99 | |
| | | Minimum | 75 | 18 | 0 | 0 | 0 | 10.1 | 0.5 | 2 | 7.7 | 90 | |
| | | No. of Samples | 48 | 19 | 44 | 25 | 31 | 15 | 15 | 32 | 32 | 17 | |
| | 350' | | INTERNATIONAL BOUNDARY | | | | | | | | | | |
| | 350' | Average | (Median)<br>2,400 | 21 | 2 | 0.05 | 17 | 11.9 | 1.3 | 5 | 8.1 | 93 | |
| | | Maximum | 46,000 | 26 | 18 | 0.56 | 24 | 17.4 | 2.8 | 25 | 8.5 | 99 | |
| | | Minimum | 30 | 18 | 0 | 0 | 0 | 9.7 | 0.3 | 1 | 7.6 | 86 | |
| | | No. of Samples | 48 | 35 | 47 | 31 | 46 | 46 | 48 | 48 | 48 | 33 | |
| | | | | | | | | | | | | | |
| | 600' | Average | (Median)<br>2,400 | 20 | 2 | 0 | 15 | 12.8 | 1.1 | 7 | 8.1 | 94 | |
| | | Maximum | 46,000 | 25 | 10 | 0.03 | 23 | 17.4 | 2.0 | 25 | 8.5 | 98 | |
| | | Minimum | < 3.0 | 18 | 0 | 0 | 0 | 10.0 | 0.4 | 1 | 7.7 | 92 | |
| | | No. of Samples | 48 | 19 | 43 | 25 | 31 | 15 | 15 | 32 | 32 | 17 | |
| | 700' | | CANADIAN SHORE | | | | | | | | | | |
| | | | | | | | | | | | | | |
| N1-7.6 A range 7.6 miles above bell buoy B-1, at Canadian Steamship Lines dock at Queenston, Ontario | | | | | | | | | | | | | |
| | 0' | | UNITED STATES SHORE | | | | | | | | | | |
| | 450' | | INTERNATIONAL BOUNDARY | | | | | | | | | | |
| | 1250' | | CANADIAN SHORE | | | | | | | | | | |
| | 1250' | Average | (Median)<br>1,600 | 23 | 2 | 0.30 | 5 | 15.7 | 2.2 | 19 | 8.0 | 92 | |
| | | Maximum | > 15,000 | 28 | 10 | 0.56 | 10 | 17.2 | 4.0 | 26 | 8.2 | 98 | |
| | | Minimum | 460 | 20 | 0 | 0.04 | 0 | 13.7 | 1.0 | 8 | 7.9 | 86 | |
| | | No. of Samples | 9 | 9 | 8 | 2 | 8 | 8 | 7 | 8 | 8 | 9 | |
| | | | | | | | | | | | | | |
| N1-6.8 A range 6.8 miles above bell buoy B-1, below Lewiston, N.Y. and Queenston, Ontario | | | | | | | | | | | | | |
| | 0' | | UNITED STATES SHORE | | | | | | | | | | |
| | 100' | Average | (Median)<br>2,400 | 20 | 4 | 0 | 16 | 11.6 | 1.6 | 4 | 8.1 | 94 | |
| | | Maximum | 24,000 | 24 | 70 | 0.02 | 22.5 | 14.3 | 2.6 | 14 | 8.5 | 97 | |
| | | Minimum | 240 | 18 | 0 | 0 | 8 | 10.0 | 0.4 | 1 | 7.7 | 90 | |
| | | No. of Samples | 34 | 10 | 32 | 13 | 18 | 8 | 8 | 19 | 19 | 9 | |
| | | | | | | | | | | | | | |
| | 1000' | Average | (Median)<br>2,400 | 22 | 1 | 0.09 | 17 | 11.7 | 1.6 | 4 | 8.1 | 93 | |
| | | Maximum | 24,000 | 27 | 8 | 0.68 | 24 | 14.3 | 3.5 | 16 | 8.5 | 98 | |
| | | Minimum | < 3.0 | 18 | 0 | 0 | 8 | 9.8 | 0.4 | 1 | 7.9 | 86 | |
| | | No. of Samples | 34 | 26 | 34 | 18 | 33 | 34 | 34 | 35 | 35 | 25 | |
| | | | | | | | | | | | | | |

## Table 19 - SUMMARY OF AVERAGE ANALYTICAL RESULTS - LOWER NIAGARA RIVER (Cont'd)

| Sampling Range and Mileage Index | Distance from East Shore | | Coliforms M.P.N. per 100ml | Chlorides ppm | Phenols ppb | Ammonia as $N_2$ ppm | Temp °C | D.O. ppm | B.O.D. 5 Day ppm | Turbidity ppm | pH | Alkalinity ppm | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ni-6.8 (Cont'd) | 1100' | | INTERNATIONAL BOUNDARY | | | | | | | | | | |
| | 1800' | Average | (Median)<br>2,400 | 20 | 2 | 0 | 16 | 11.5 | 1.4 | 5 | 8.1 | 94 | |
| | | Maximum | 4,600 | 23 | 35 | 0.02 | 22.5 | 14.3 | 2.2 | 15 | 8.6 | 97 | |
| | | Minimum | 93 | 18 | 0 | 0 | 8 | 10.3 | 0.9 | 1 | 7.9 | 92 | |
| | | No. of Samples | 34 | 10 | 32 | 13 | 18 | 8 | 8 | 19 | 19 | 9 | |
| | 1900' | | CANADIAN SHORE | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| Ni-2.4 A range 2.4 miles above bell buoy B-1, above Youngstown, N.Y. and Niagara-on-the-Lake, Ontario | 0' | | UNITED STATES SHORE | | | | | | | | | | |
| | 100' | Average | (Median)<br>2,400 | 20 | 1 | 0 | 17 | 11.6 | 1.8 | 6 | 8.1 | 94 | |
| | | Maximum | 9,300 | 24 | 10 | 0.02 | 22.5 | 14.1 | 3.1 | 13 | 8.5 | 98 | |
| | | Minimum | 150 | 17 | 0 | 0 | 8 | 10.3 | 0.9 | 1 | 7.9 | 90 | |
| | | No. of Samples | 40 | 16 | 37 | 19 | 24 | 8 | 8 | 25 | 25 | 14 | |
| | | | | | | | | | | | | | |
| | 800' | Average | (Median)<br>2,300 | 21 | 2 | 0.06 | 18 | 11.3 | 1.6 | 5 | 8.1 | 93 | |
| | | Maximum | 11,000 | 27 | 35 | 0.66 | 24 | 14.1 | >8.3 | 14 | 8.5 | 99 | |
| | | Minimum | 210 | 18 | 0 | 0 | 8 | 9.7 | 0.5 | 1 | 7.2 | 84 | |
| | | No. of Samples | 39 | 32 | 39 | 24 | 39 | 39 | 39 | 41 | 41 | 30 | |
| | 850' | | INTERNATIONAL BOUNDARY | | | | | | | | | | |
| | 1700' | Average | (Median)<br>2,300 | 20 | 1 | 0 | 17 | 11.7 | 1.6 | 6 | 8.1 | 94 | |
| | | Maximum | 24,000 | 28 | 10 | 0.06 | 22.5 | 13.9 | 3.1 | 18 | 8.5 | 98 | |
| | | Minimum | < 3.0 | 17 | 0 | 0 | 8 | 10.2 | 0.8 | 1 | 7.9 | 90 | |
| | | No. of Samples | 39 | 16 | 36 | 19 | 24 | 8 | 8 | 25 | 25 | 14 | |
| | 1800' | | CANADIAN SHORE | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| Ni-1.0 A range across lower Niagara River at United States Coast Guard Station, one mile from bell buoy B-1 | 0' | | UNITED STATES SHORE | | | | | | | | | | |
| | 100' | Average | (Median)<br>2,300 | 20 | 2 | 0.01 | 17 | 11.7 | 1.3 | 5 | 8.2 | 94 | |
| | | Maximum | 24,000 | 24 | 65 | 0.07 | 23 | 14.0 | 2.0 | 13 | 8.5 | 100 | |
| | | Minimum | 93 | 18 | 0 | 0 | 8 | 10.4 | 0.7 | 1 | 7.7 | 84 | |
| | | No. of Samples | 65 | 19 | 62 | 24 | 29 | 12 | 11 | 31 | 31 | 16 | |
| | | | | | | | | | | | | | |
| | 400' | Average | (Median)<br>4,300 | 19 | 0 | 0 | 19 | 10.5 | 1.2 | 6 | 8.2 | 95 | |
| | | Maximum | 4,300 | 21 | Trace | 0.03 | 23 | 10.6 | 1.4 | 14 | 8.5 | [illegible] | |
| | | Minimum | 930 | 18 | 0 | 0 | 12 | 10.4 | 1.0 | 2 | 7.9 | 91 | |
| | | No. of Samples | 16 | 14 | 15 | 14 | 15 | 2 | 2 | 16 | 16 | 11 | |
| | 800' | | INTERNATIONAL BOUNDARY | | | | | | | | | | |
| | 800' | Average | (Median)<br>2,400 | 21 | 1 | 0.04 | 18 | 11.6 | 1.3 | 4 | 8.1 | 92 | |
| | | Maximum | 24,000 | 27 | 10 | 0.66 | 24 | 14.2 | 4.6 | 14 | 8.5 | 103 | |
| | | Minimum | 93 | 17 | 0 | 0 | 8 | 9.7 | 0.1 | 1 | 7.2 | 72 | |
| | | No. of Samples | 69 | 57 | 67 | 40 | 59 | 49 | 55 | 69 | 66 | 53 | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |

## Table 19 - SUMMARY OF AVERAGE ANALYTICAL RESULTS - LOWER NIAGARA RIVER (Cont'd)

| Sampling Range and Mileage Index | Distance from East Shore | | Coliforms M.P.N. per 100ml | Chlorides ppm | Phenols ppb | Ammonia as $N_2$ ppm | Temp. °C | D.O. ppm | B.O.D. 5 Day ppm | Turbidity ppm | pH | Alkalinity ppm | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| N1-1.0 (Cont'd) | | | | | | | | | | | | | |
| | 1800' | Average | (Median) 2,300 | 19 | 1 | 0 | 19 | 10.5 | 0.9 | 6 | 8.2 | 95 | |
| | | Maximum | 9,300 | 20 | 15 | 0.02 | 23 | 10.7 | 1.0 | 14 | 8.5 | 99 | |
| | | Minimum | 230 | 17 | 0 | 0 | 12 | 10.3 | 0.7 | 2 | 7.9 | 92 | |
| | | No. of Samples | 16 | 14 | 15 | 14 | 15 | 2 | 2 | 16 | 16 | 11 | |
| | 1400' | Average | (Median) 1,500 | 20 | 1 | 0 | 17 | 11.5 | 1.1 | 5 | 8.1 | 94 | |
| | | Maximum | 15,000 | 23 | 50 | 0.04 | 23 | 13.8 | 2.0 | 13 | 8.5 | 98 | |
| | | Minimum | < 3.0 | 17 | 0 | 0 | 8 | 10.0 | 0.3 | 1 | 7.7 | 91 | |
| | | No. of Samples | 65 | 19 | 61 | 24 | 29 | 12 | 11 | 31 | 31 | 16 | |
| | 1800' | | CANADIAN SHORE | | | | | | | | | | |
| | | | LOWER | NIAGARA | | RIVER | TRIBUTARIES | | | | | | |
| NiPC-9.0 Hydro Electric Power Commission's power canal at discharge to lower Niagara River at Queenston, Ontario | | Average | (Median) 2,000 | 19 | 0 | 0.26 | 5 | 12.5 | 1.5 | 20 | 7.9 | 91 | |
| | | Maximum | 11,000 | 25 | Trace | 0.48 | 12 | 14.2 | 4.1 | 50 | 8.1 | 100 | |
| | | Minimum | 400 | 15 | 0 | 0.04 | 0 | 10.3 | 0.2 | 6 | 7.9 | 78 | |
| | | No. of Samples | 18 | 18 | 15 | 2 | 14 | 16 | 13 | 17 | 17 | 18 | |
| NiPC-16.2 Hydro Electric Power Commission's power canal at Allanburg-Chippawa Highway, 1.6 miles from its junction with the Welland River | | Average | (Median) 1,430 | 19 | 0 | | 11 | 11.2 | 0.7 | 26 | 7.9 | 92 | |
| | | Maximum | 11,000 | 20 | 0 | | 11 | 12.4 | 1.5 | 54 | 8.0 | 94 | |
| | | Minimum | 150 | 19 | 0 | | 11 | 10.3 | 0 | 9 | 7.9 | 90 | |
| | | No. of Samples | 4 | 4 | 4 | | 2 | 4 | 4 | 4 | 4 | 4 | |
| NiPCWe-18.3<br>Welland River 0.5 miles west of junction with Hydro Electric Power Commission's power canal | | Average | (Median) 2,400 | 18 | 3 | 2.2 | 3 | 10.5 | 2.7 | 49 | 7.3 | 79 | |
| | | Maximum | 28,000 | 36 | 10 | 4.4 | 4 | 11.4 | 3.8 | 150 | 8.1 | 94 | |
| | | Minimum | 1,100 | 4.1 | 0 | 0.48 | 2 | 9.1 | 0.8 | 4 | 6.4 | 48 | |
| | | No. of Samples | 7 | 7 | 7 | 3 | 4 | 7 | 6 | 7 | 7 | 7 | |

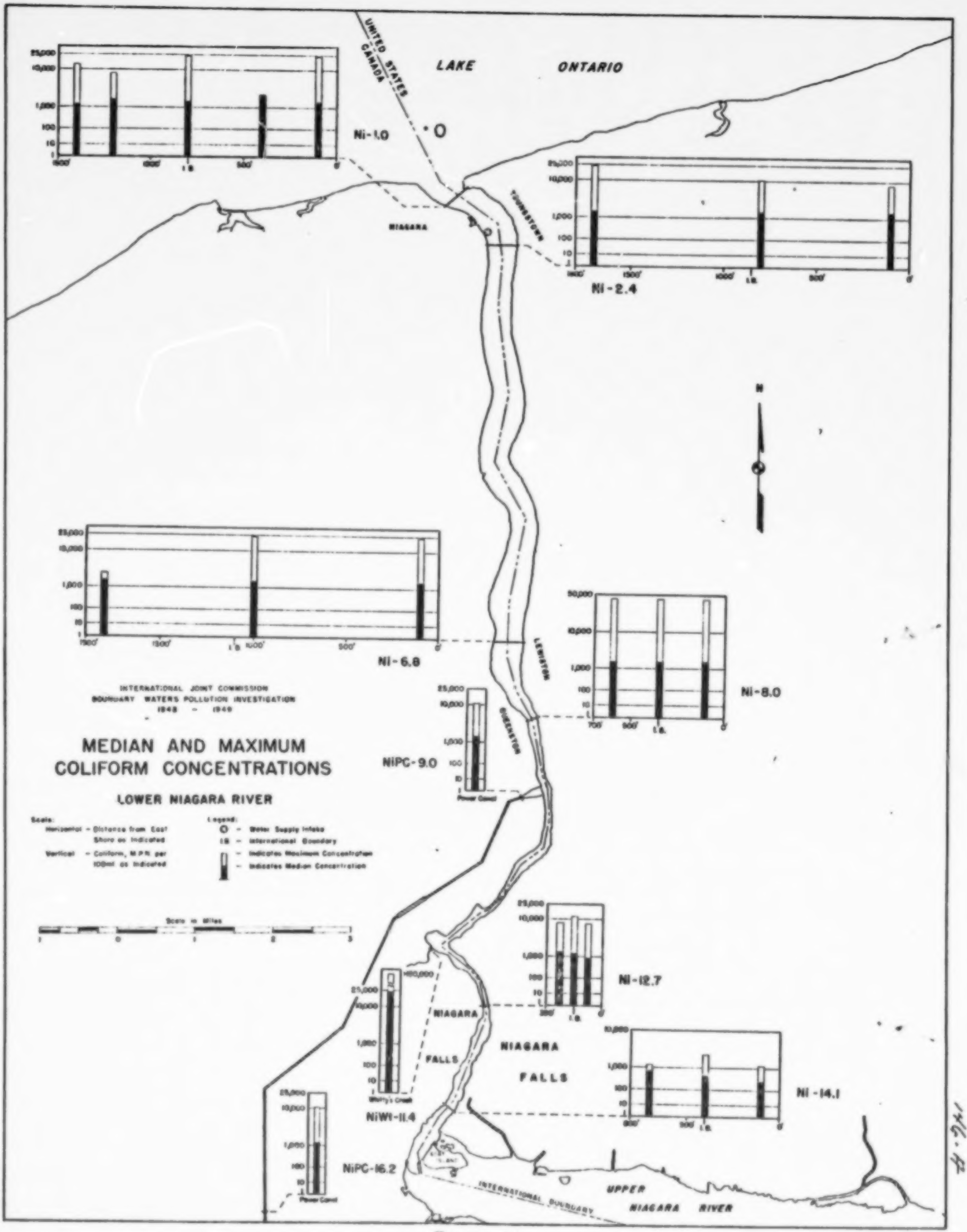
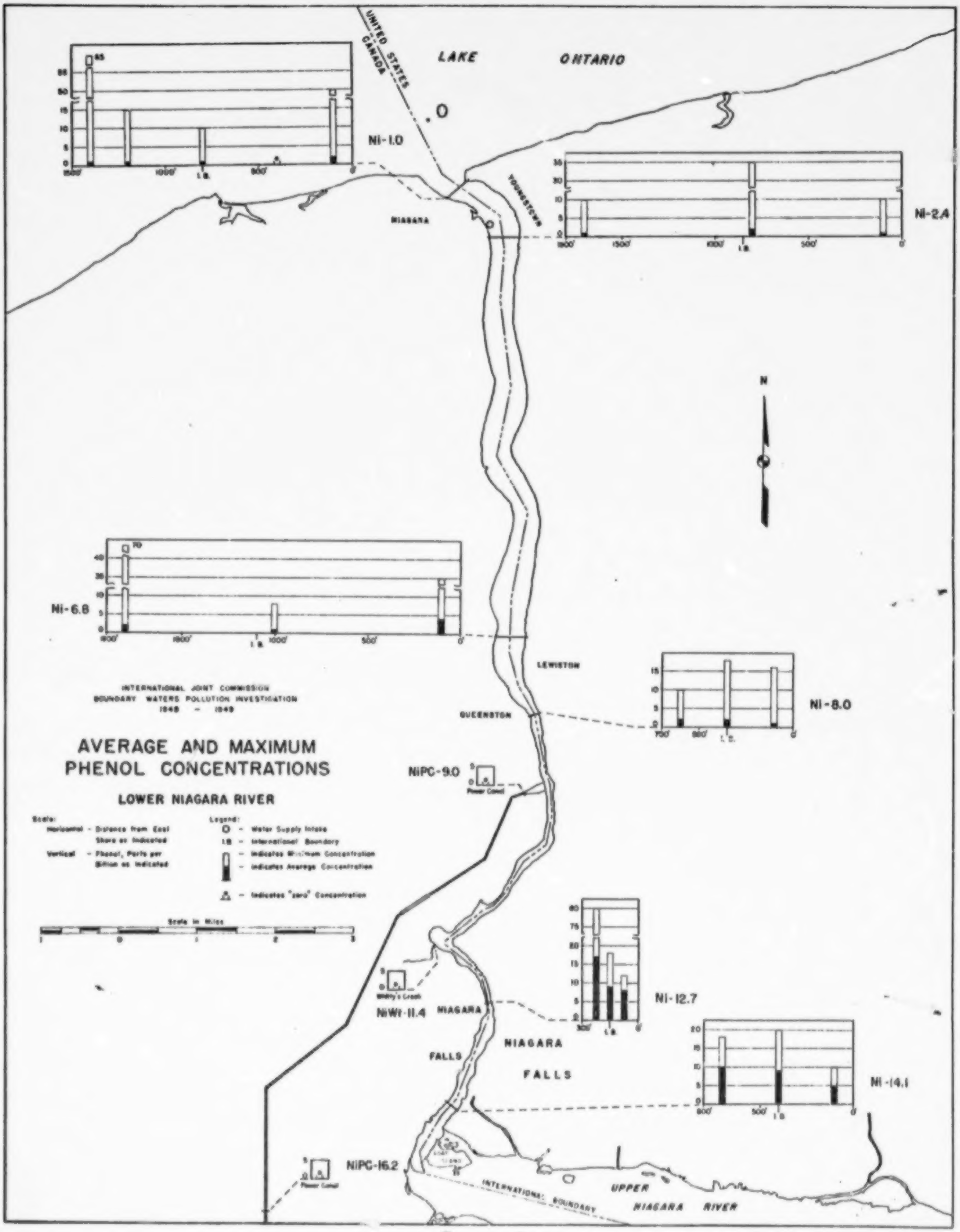

LAKE ONTARIO
UNITED STATES
CANADA
NIAGARA
YOUNGSTOWN
LEWISTON
QUEENSTON
NIAGARA FALLS
NIAGARA FALLS
INTERNATIONAL BOUNDARY
UPPER NIAGARA RIVER
N
Ni-1.0
Ni-2.4
Ni-6.8
Ni-8.0
NiPC-9.0
Ni-12.7
NiWi-11.4
NiPC-16.2
Ni-14.1
Power Canal
Whitty's Creek
25,000
10,000
1,000
100
10
1
50,000
100,000
1900'
1500'
1000'
500'
0'
I.B.
INTERNATIONAL JOINT COMMISSION
BOUNDARY WATERS POLLUTION INVESTIGATION
1948 - 1949
MEDIAN AND MAXIMUM
COLIFORM CONCENTRATIONS
LOWER NIAGARA RIVER
Scale:
Horizontal - Distance from East Shore as Indicated
Vertical - Coliform, M.P.N. per 100ml as Indicated
Legend:
O - Water Supply Intake
I.B. - International Boundary
- Indicates Maximum Concentration
- Indicates Median Concentration
Scale in Miles
1 0 1 2 3

FIGURE 7



LAKE ONTARIO
UNITED STATES
CANADA
NIAGARA
YOUNGSTOWN
LEWISTON
QUEENSTON
NIAGARA
FALLS
NIAGARA
FALLS
INTERNATIONAL BOUNDARY
UPPER NIAGARA RIVER
N
NI-1.0
NI-2.4
NI-6.8
NI-8.0
NIPC-9.0
Power Canal
NIWI-11.4
Welly's Creek
NI-12.7
NI-14.1
NIPC-16.2
Power Canal
I.B.
Scale in Miles
1
0
1
2
3

INTERNATIONAL JOINT COMMISSION
BOUNDARY WATERS POLLUTION INVESTIGATION
1948 - 1949

## AVERAGE AND MAXIMUM PHENOL CONCENTRATIONS

### LOWER NIAGARA RIVER

Scale:
Horizontal - Distance from East Shore as Indicated
Vertical - Phenol, Parts per Billion as Indicated

Legend:
○ - Water Supply Intake
I.B. - International Boundary
▯ - Indicates Maximum Concentration
▮ - Indicates Average Concentration
△ - Indicates "zero" Concentration

Fig. 8

Lake Ontario

A U. S. Weather Bureau report of 1895 stated that the normal flow of water in Lake Ontario along the south shore is in an easterly direction. However, the summary of analytical results presented in table 20 does not show that the pollution from the lower Niagara River follows this direction. The median and maximum coliform, and the average and maximum phenol values are depicted in figures 9 and 10.

The median M.P.N. coliform values varied from 43 to 1,100 per 100 ml. at a distance of 1.5 miles from the outlet of the Niagara River. The smaller values were noted toward the east, and the larger toward the northwest. Progressing outward from Point "O" along the fan-like ranges, the median coliform values steadily decrease, until relatively unpolluted water prevails at a distance 10 miles from the outlet of the river. The two ranges OE and OC extending eastward showed M.P.N. median values varying from 23 to 587 per 100 ml., with a maximum of 1,500. In comparison, median values of from 3.6 to 2,400 per 100 ml. and a maximum of 11,000 were found on the other radial ranges. An increase in coliform values at the west end of range ON-2 through ON-8 is undoubtedly caused by bacterial pollution entering Lake Ontario in the vicinity of the old Welland Ship Canal outlet at Port Dalhousie, Ontario.

Average and maximum phenol values were low throughout the section of Lake Ontario under investigation. Average values varied from 0 to 5 p.p.b. with most values being less than 2 p.p.b. A maximum result of 85 p.p.b. was reported on range ON three miles from Point "O". With the exception of five other results in the order of 12 to 25 p.p.b., all the maximum values were less than 8 p.p.b. and over half of the maximum values were less than 3 p.p.b.

Other analytical results indicate the same conditions as shown by the phenol analyses. Turbidity and B.O.D. averages were low, and chlorides and alkalinity remained unchanged.

Table 20 - SUMMARY OF AVERAGE ANALYTICAL RESULTS - LAKE ONTARIO

| Sampling Range and Location | Station (Miles) | | Coliforms M.P.N. per 100ml. | Chlorides ppm | Phenols ppb | Ammonia as $N_2$ ppm | Temp. °C | D.O. ppm | B.O.D. 5 Day ppm | Turbidity ppm | pH | Alkalinity ppm | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| "0" Point "0" is the bell buoy B-1, located about one mile from the outlet of Niagara River. It is the zero point for the radial sampling ranges in Lake Ontario | 0 | Average | (Median) 695 | 23 | 2 | 0.06 | 17 | 12.3 | 2.0 | 4 | 8.1 | 92 | |
| | | Maximum | 4,300 | 37 | 20 | 0.96 | 24 | 13.5 | 4.5 | 15 | 8.8 | 98 | |
| | | Minimum | 23 | 17 | 0 | 0 | 8 | 10.7 | 0.3 | 1 | 7.2 | 78 | |
| | | No. of Samples | 42 | 37 | 41 | 28 | 33 | 18 | 26 | 42 | 41 | 36 | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| OW A range westerly from point "0" on a bearing of S 76°W roughly parallel to the Canadian shore | 0.5 | Average | (Median) 1,100 | 22 | 1 | <0.01 | 20 | 12.4 | 1.4 | 3 | 8.3 | 95 | |
| | | Maximum | 2,400 | 22 | 4 | 0.01 | 24 | 12.9 | 1.7 | 6 | 3.3 | 98 | |
| | | Minimum | 150 | 21 | 0 | Trace | 13 | 11.9 | 1.1 | 1 | 8.3 | 92 | |
| | | No. of Samples | 10 | 3 | 10 | 2 | 5 | 2 | 3 | 5 | 5 | 3 | |
| | | | | | | | | | | | | | |
| | 1.0 | Average | (Median) 1,100 | 23 | 1 | 0.15 | 18 | 12.3 | 1.6 | 4 | 8.1 | 93 | |
| | | Maximum | 11,000 | 24 | 6 | 0.58 | 24 | 12.7 | 2.7 | 6 | 8.3 | 95 | |
| | | Minimum | 28 | 21 | 0 | 0 | 12 | 11.8 | 0.7 | 1 | 7.2 | 90 | |
| | | No. of Samples | 11 | 6 | 12 | 5 | 6 | 3 | 6 | 8 | 8 | 6 | |
| | | | | | | | | | | | | | |
| | 2.0 | Average | (Median) 780 | 23 | 2 | 0.03 | 19 | 11.9 | 0.9 | 3 | 8.3 | 93 | |
| | | Maximum | 4,600 | 25 | 6 | 0.10 | 24 | 12.2 | 1.2 | 5 | 8.3 | 96 | |
| | | Minimum | 21 | 20 | 0 | 0 | 11 | 11.7 | 0.3 | 1 | 8.2 | 91 | |
| | | No. of Samples | 10 | 6 | 9 | 3 | 8 | 3 | 6 | 8 | 8 | 6 | |
| | | | | | | | | | | | | | |
| | 3.0 | Average | (Median) 1,665 | 23 | 0 | 0.16 | 21 | 11.9 | 1.1 | 3 | 8.2 | 95 | |
| | | Maximum | 2,400 | 25 | 4 | 0.44 | 24 | 12.2 | 1.6 | 6 | 8.4 | 96 | |
| | | Minimum | 93 | 21 | 0 | Trace | 12 | 11.6 | 0.6 | 1 | 7.9 | 92 | |
| | | No. of Samples | 10 | 5 | 10 | 3 | 4 | 2 | 4 | 6 | 6 | 5 | |
| | | | | | | | | | | | | | |
| | 4.0 | Average | (Median) 980 | 23 | 1 | Trace | 19 | 12.3 | 1.4 | 3 | 8.3 | 92 | |
| | | Maximum | 4,600 | 26 | 5 | Trace | 24 | 13.0 | 2.3 | 7 | 8.3 | 96 | |
| | | Minimum | 43 | 17 | 0 | 0 | 12 | 11.5 | 0.8 | 1 | 8.1 | 88 | |
| | | No. of Samples | 10 | 7 | 8 | 2 | 8 | 3 | 6 | 6 | 8 | 7 | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| OT A range from the point "0" on a bearing at N 56°W | 0.5 | Average | (Median) 1,100 | 20 | 1 | Trace | 19 | 12.5 | | 3 | 8.3 | 96 | |
| | | Maximum | 2,400 | 21 | 4 | Trace | 24 | 12.5 | | 4 | 8.4 | 96 | |
| | | Minimum | 150 | 18 | 0 | 0 | 13 | 12.5 | | 2 | 8.1 | 96 | |
| | | No. of Samples | 17 | 2 | 14 | 2 | 2 | 1 | | 3 | 3 | 2 | |
| | | | | | | | | | | | | | |
| | 1.0 | Average | (Median) 1,100 | 23 | 1 | 0.18 | 21 | 12.2 | 1.4 | 3 | 8.2 | 94 | |
| | | Maximum | 4,600 | 24 | 6 | 0.68 | 24 | 12.2 | 2.0 | 7 | 8.3 | 98 | |
| | | Minimum | 75 | 18 | 0 | 0 | 13 | 12.2 | 0.9 | 1 | 7.9 | 88 | |
| | | No. of Samples | 19 | 6 | 17 | 4 | 4 | 1 | 4 | 7 | 7 | 6 | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |

## Table 20 - SUMMARY OF AVERAGE ANALYTICAL RESULTS - LAKE ONTARIO (Cont'd)

| Sampling Range and Location | Station (Miles) | | Coliforms M.P.N. per 100ml. | Chlorides ppm | Phenols ppb | Ammonia as N$_2$ ppm | Temp. °C | D.O. ppm | B.O.D. 5 Day ppm | Turbidity ppm | pH | Alkalinity ppm | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OT (Cont'd) | 2.0 | Average | (Median) 1,100 | 23 | 1 | 0 | 16 | 12.0 | 1.4 | 3 | 8.2 | 92 | |
| | | Maximum | 11,000 | 25 | 7 | Trace | 24 | 12.5 | 3.8 | 6 | 8.4 | 98 | |
| | | Minimum | 3.6 | 18 | 0 | 0 | 12 | 11.6 | 0.6 | 2 | 8.0 | 88 | |
| | | No. of Samples | 23 | 10 | 18 | 8 | 9 | 6 | 7 | 11 | 11 | 10 | |
| | | | | | | | | | | | | | |
| | 3.0 | Average | (Median) 350 | 22 | 1 | Trace | 21 | 11.8 | 1.1 | 2 | 8.3 | 94 | |
| | | Maximum | 11,000 | 24 | 6 | Trace | 24 | 11.8 | 1.6 | 3 | 8.5 | 96 | |
| | | Minimum | < 3.0 | 19 | 0 | 0 | 13 | 11.8 | 0.6 | 1 | 8.1 | 92 | |
| | | No. of Samples | 18 | 4 | 14 | 2 | 4 | 1 | 2 | 5 | 5 | 4 | |
| | | | | | | | | | | | | | |
| | 4.0 | Average | (Median) 305 | 22 | 1 | 0.04 | 16 | 12.1 | 1.3 | 3 | 8.2 | 92 | |
| | | Maximum | 11,000 | 26 | 5 | 0.36 | 24 | 13.0 | 2.2 | 9 | 8.4 | 97 | |
| | | Minimum | 3.6 | 14 | 0 | 0 | 11 | 11.7 | 0.6 | 1 | 7.9 | 88 | |
| | | No. of Samples | 18 | 15 | 18 | 10 | 10 | 8 | 10 | 16 | 16 | 15 | |
| | | | | | | | | | | | | | |
| | 5.0 | Average | (Median) 68 | | 0 | | | | | | | | |
| | | Maximum | > 1,500 | | Trace | | | | | | | | |
| | | Minimum | < 3.0 | | 0 | | | | | | | | |
| | | No. of Samples | 6 | | 5 | | | | | | | | |
| | | | | | | | | | | | | | |
| | 6.0 | Average | (Median) 23 | 23 | 0 | 0 | 14 | 12.1 | 1.1 | 2 | 8.1 | 93 | |
| | | Maximum | 1,100 | 25 | Trace | 0 | 20 | 12.4 | 1.5 | 2 | 8.2 | 96 | |
| | | Minimum | 9.1 | 19 | 0 | 0 | 10 | 11.7 | 0.8 | 1 | 8.0 | 90 | |
| | | No. of Samples | 7 | 6 | 7 | 6 | 5 | 4 | 4 | 6 | 6 | 6 | |
| | | | | | | | | | | | | | |
| | 7.0 | Average | (Median) 23 | | 0 | | | | | | | | |
| | | Maximum | > 1,500 | | Trace | | | | | | | | |
| | | Minimum | < 3.0 | | 0 | | | | | | | | |
| | | No. of Samples | 6 | | 5 | | | | | | | | |
| | | | | | | | | | | | | | |
| | 8.0 | Average | (Median) 3.6 | 24 | 1 | 0 | 13 | 12.1 | 1.2 | 1 | 8.1 | 93 | |
| | | Maximum | 460 | 28 | 4 | 0 | 19 | 12.8 | 2.0 | 2 | 8.3 | 96 | |
| | | Minimum | < 3.0 | 19 | 0 | 0 | 10 | 11.3 | 0.8 | 1 | 8.0 | 88 | |
| | | No. of Samples | 7 | 7 | 7 | 6 | 5 | 4 | 5 | 7 | 7 | 7 | |
| | | | | | | | | | | | | | |
| OM A range from point "C" on a bearing of N 27°W parallel to the International Boundary | 0.5 | Average | (Median) 1,100 | | 2 | Trace | 14 | 11.4 | 1.2 | 4 | 8.0 | | |
| | | Maximum | 2,400 | | 8 | Trace | 14 | 11.4 | 1.2 | 4 | 8.0 | | |
| | | Minimum | 93 | | 0 | Trace | 14 | 11.4 | 1.2 | 4 | 8.0 | | |
| | | No. of Samples | 4 | | 4 | 1 | 1 | 1 | 1 | 1 | 1 | | |
| | | | | | | | | | | | | | |
| | 1.0 | Average | (Median) > 1,500 | | 0 | Trace | 14 | 11.8 | 1.1 | 4 | 8.1 | | |
| | | Maximum | 2,400 | | Trace | Trace | 14 | 11.8 | 1.1 | 4 | 8.1 | | |
| | | Minimum | 430 | | 0 | Trace | 14 | 11.8 | 1.1 | 4 | 8.1 | | |
| | | No. of Samples | 4 | | 4 | 1 | 1 | 1 | 1 | 1 | 1 | | |

## Table 20 - SUMMARY OF AVERAGE ANALYTICAL RESULTS - LAKE ONTARIO (Cont'd)

| Sampling Range and Location | Station (Miles) | | Coliforms M.P.N. per 100ml | Chlorides ppm | Phenols ppb | Ammonia as $N_2$ ppm | Temp. °C | D.O. ppm | B.O.D. 5 Day ppm | Turbidity ppm | pH | Alkalinity ppm | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| [illegible] (Cont'd) | 2.0 | Average | (Median) 1,800 | | 1 | Trace | 14 | 12.1 | 0.9 | 4 | 8.1 | | |
| | | Maximum | 2,400 | | 3 | Trace | 14 | 12.1 | 0.9 | 4 | 8.1 | | |
| | | Minimum | 430 | | 0 | Trace | 14 | 12.1 | 0.9 | 4 | 8.1 | | |
| | | No. of Samples | 4 | | 4 | 1 | 1 | 1 | 1 | 1 | 1 | | |
| | | | | | | | | | | | | | |
| | 3.0 | Average | (Median) 1,800 | 19 | 1 | Trace | 14 | 12.0 | 0.9 | 3 | 8.0 | 90 | |
| | | Maximum | 2,400 | 19 | 3 | Trace | 14 | 12.0 | 1.3 | 4 | 8.1 | 90 | |
| | | Minimum | 750 | 19 | 0 | Trace | 14 | 12.0 | 0.5 | 3 | 7.9 | 90 | |
| | | No. of Samples | 4 | 2 | 4 | 1 | 1 | 1 | 2 | 3 | 3 | 2 | |
| | | | | | | | | | | | | | |
| | 4.0 | Average | (Median) 460 | 24 | 1 | Trace | 19 | 12.0 | 0.8 | 3 | 8.1 | 90 | |
| | | Maximum | > 1,500 | 24 | 4 | Trace | 23 | 12.0 | 0.8 | 4 | 8.1 | 90 | |
| | | Minimum | 230 | 24 | 0 | 0 | 14 | 12.0 | 0.8 | 1 | 8.1 | 90 | |
| | | No. of Samples | 4 | 1 | 4 | 2 | 2 | 1 | 1 | 2 | 2 | 1 | |
| | | | | | | | | | | | | | |
| | 5.0 | Average | (Median) 1,100 | | 0 | | | | | | | | |
| | | Maximum | 1,100 | | 0 | | | | | | | | |
| | | Minimum | 1,100 | | 0 | | | | | | | | |
| | | No. of Samples | 3 | | 3 | | | | | | | | |
| | | | | | | | | | | | | | |
| | 6.0 | Average | (Median) 1,215 | 20 | 1 | 0.01 | 14 | 12.1 | 0.7 | 3 | 8.0 | 90 | |
| | | Maximum | > 1,500 | 20 | 3 | 0.01 | 14 | 12.1 | 0.8 | 3 | 8.2 | 90 | |
| | | Minimum | 460 | 19 | 0 | 0.01 | 14 | 12.1 | 0.5 | 3 | 7.9 | 90 | |
| | | No. of Samples | 4 | 2 | 4 | 1 | 1 | 1 | 2 | 3 | 3 | 2 | |
| | | | | | | | | | | | | | |
| | 8.0 | Average | (Median) 19 | 23 | Trace | Trace | 18 | 11.8 | 0.5 | 2 | 8.4 | 92 | |
| | | Maximum | 23 | 23 | Trace | Trace | 22 | 11.8 | 0.5 | 2 | 8.5 | 92 | |
| | | Minimum | 15 | 23 | 0 | 0 | 14 | 11.8 | 0.5 | 1 | 8.2 | 92 | |
| | | No. of Samples | 2 | 1 | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 1 | |
| | | | | | | | | | | | | | |
| | 10.0 | Average | (Median) 3.6 | | 2 | Trace | 14 | 13.1 | 0.7 | 2 | 8.0 | | |
| | | Maximum | 7.3 | | 3 | Trace | 14 | 13.1 | 0.7 | 2 | 8.0 | | |
| | | Minimum | < 3.0 | | 0 | Trace | 14 | 13.1 | 0.7 | 2 | 8.0 | | |
| | | No. of Samples | 2 | | 2 | 1 | 1 | 1 | 1 | 1 | 1 | | |
| | | | | | | | | | | | | | |
| CN A range from point "O" on a bearing of N 3°E | 0.5 | Average | (Median) 240 | 20 | 1 | 0.01 | 18 | 12.0 | 1.5 | 5 | 8.2 | 95 | |
| | | Maximum | 4,600 | 23 | 16 | 0.06 | 23 | 13.6 | 3.1 | 15 | 8.5 | 97 | |
| | | Minimum | 23 | 18 | 0 | 0 | 9 | 10.9 | 0.7 | 2 | 8.0 | 93 | |
| | | No. of Samples | 30 | 6 | 26 | 8 | 8 | 3 | 4 | 9 | 9 | 4 | |
| | | | | | | | | | | | | | |
| | 1.0 | Average | (Median) 240 | 20 | 2 | 0 | 18 | 12.2 | 1.0 | 4 | 8.3 | 95 | |
| | | Maximum | 4,600 | 20 | 14 | 0.02 | 23 | 13.6 | 1.0 | 12 | 8.5 | 96 | |
| | | Minimum | 9.1 | 18 | 0 | 0 | 9 | 11.3 | 0.9 | 2 | 8.0 | 93 | |
| | | No. of Samples | 30 | 4 | 25 | 7 | 8 | 3 | 2 | 8 | 8 | 3 | |

## Table 20 - SUMMARY OF AVERAGE ANALYTICAL RESULTS - LAKE ONTARIO (Cont'd)

| Sampling Range and Location | Station (Miles) | | Coliforms M.P.N. per 100ml. | Chlorides ppm | Phenols ppb | Ammonia as $N_2$ ppm | Temp. °C | D.O. ppm | B.O.D. 5 Day ppm | Turbidity ppm | pH | Alkalinity ppm | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ON (Cont'd) | 2.0 | Average | (Median) 430 | 23 | 1 | 0.02 | 18 | 12.0 | 1.5 | 3 | 8.1 | 98 | |
| | | Maximum | 11,000 | 28 | 6 | 0.48 | 23 | 13.6 | 3.8 | 10 | 8.5 | 96 | |
| | | Minimum | 3.6 | 19 | 0 | 0 | 9 | 11.2 | 0.8 | 1 | 6.7 | 86 | |
| | | No. of Samples | 35 | 25 | 32 | 23 | 25 | 10 | 16 | 29 | 29 | 24 | |
| | 3.0 | Average | (Median) 460 | 21 | 3 | 0 | 18 | 12.4 | 1.0 | 4 | 8.3 | 94 | |
| | | Maximum | 11,000 | 25 | 85 | Trace | 23 | 13.4 | 1.3 | 13 | 8.5 | 95 | |
| | | Minimum | 23 | 18 | 0 | 0 | 6 | 11.2 | 0.5 | 2 | 8.0 | 90 | |
| | | No. of Samples | 29 | 5 | 26 | 7 | 8 | 4 | 4 | 9 | 9 | 4 | |
| | 4.0 | Average | (Median) 430 | 22 | 1 | 0.05 | 17 | 12.1 | 1.5 | 3 | 8.2 | 92 | |
| | | Maximum | 2,400 | 26 | 6 | 0.58 | 23 | 13.4 | 3.5 | 9 | 8.6 | 99 | |
| | | Minimum | 9.1 | 17 | 0 | 0 | 7 | 11.2 | 0.3 | 1 | 7.3 | 78 | |
| | | No. of Samples | 29 | 26 | 28 | 19 | 23 | 12 | 20 | 29 | 29 | 25 | |
| | 5.0 | Average | (Median) 93 | | 0 | | | | | | | | |
| | | Maximum | > 1,500 | | Trace | | | | | | | | |
| | | Minimum | < 3.0 | | 0 | | | | | | | | |
| | | No. of Samples | 10 | | 9 | | | | | | | | |
| | 6.0 | Average | (Median) 33 | 23 | 0 | 0.01 | 13 | 12.0 | 1.5 | 3 | 8.1 | 98 | |
| | | Maximum | 1,100 | 24 | Trace | 0.12 | 19 | 13.0 | 2.7 | 8 | 8.4 | 96 | |
| | | Minimum | < 3.0 | 18 | 0 | 0 | 9 | 11.3 | 0.7 | 1 | 8.0 | 88 | |
| | | No. of Samples | 12 | 10 | 11 | 10 | 8 | 7 | 7 | 10 | 10 | 9 | |
| | 7.0 | Average | (Median) 43 | | 1 | | | | | | | | |
| | | Maximum | 460 | | 4 | | | | | | | | |
| | | Minimum | < 3.0 | | 0 | | | | | | | | |
| | | No. of Samples | 9 | | 8 | | | | | | | | |
| | 8.0 | Average | (Median) 15 | 22 | 1 | 0.01 | 14 | 12.1 | 1.1 | 3 | 8.1 | 98 | |
| | | Maximum | 430 | 25 | 7 | 0.06 | 24 | 13.1 | 1.7 | 10 | 8.7 | 96 | |
| | | Minimum | < 3.0 | 18 | 0 | 0 | 8 | 11.0 | 0.4 | 1 | 7.2 | 90 | |
| | | No. of Samples | 11 | 11 | 10 | 10 | 10 | 7 | 7 | 11 | 11 | 10 | |
| | 10.0 | Average | (Median) 15 | 22 | 2 | 0.3 | 12 | 13.2 | 0.9 | 6 | 8.1 | 96 | |
| | | Maximum | 64 | 25 | 3 | 0.6 | 16 | 13.2 | 0.9 | 7 | 8.1 | 96 | |
| | | Minimum | < 3.6 | 18 | 0 | 0 | 7 | 13.2 | 0.9 | 4 | 8.0 | 96 | |
| | | No. of Samples | 3 | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 1 | |

Table 20 - SUMMARY OF AVERAGE ANALYTICAL RESULTS - LAKE ONTARIO (Cont'd)

| Sampling Range and Location | Station (Miles) | | Coliforms M.P.N. per 100ml. | Chlorides ppm | Phenols ppb | Ammonia as $N_2$ ppm | Temp. °C | D.O. ppm | B.O.D. 5 Day ppm | Turbidity ppm | pH | Alkalinity ppm | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OC A range from point "O" on a bearing N 45°E | 0.5 | Average | (Median) 150 | 42 | 1 | 1.5 | 9 | 13.5 | 0.9 | 5 | 7.8 | 89 | |
| | | Maximum | 460 | 42 | 6 | 3.0 | 10 | 13.5 | 0.9 | 6 | 7.9 | 89 | |
| | | Minimum | 7.3 | 42 | 0 | 0 | 8 | 13.5 | 0.9 | 3 | 7.6 | 89 | |
| | | No. of Samples | 5 | 1 | 5 | 2 | 2 | 1 | 1 | 2 | 2 | 1 | |
| | | | | | | | | | | | | | |
| | 1.0 | Average | (Median) 84 | 38 | 0 | 1.5 | 9 | 13.2 | 0.6 | 5 | 7.9 | 88 | |
| | | Maximum | 460 | 38 | Trace | 3.0 | 10 | 13.2 | 0.6 | 7 | 7.9 | 88 | |
| | | Minimum | 23 | 38 | 0 | 0 | 8 | 13.2 | 0.6 | 3 | 7.8 | 88 | |
| | | No. of Samples | 6 | 1 | 6 | 2 | 2 | 1 | 1 | 2 | 2 | 1 | |
| | | | | | | | | | | | | | |
| | 2.0 | Average | (Median) 43 | 24 | 5 | 0.18 | 11 | 12.1 | 1.3 | 2 | 8.0 | 91 | |
| | | Maximum | 93 | 27 | 25 | 0.92 | 16 | 13.2 | 1.9 | 5 | 8.1 | 97 | |
| | | Minimum | < 3.0 | 23 | 0 | 0 | 6 | 10.9 | 0.6 | 1 | 7.9 | 88 | |
| | | No. of Samples | 5 | 4 | 5 | 5 | 3 | 2 | 2 | 5 | 4 | 4 | |
| | | | | | | | | | | | | | |
| | 3.0 | Average | (Median) 93 | | 2 | 0.3 | 8 | 13.2 | 0.5 | 3 | 8.0 | | |
| | | Maximum | 460 | | 8 | 0.6 | 10 | 13.2 | 0.5 | 4 | 8.0 | | |
| | | Minimum | < 3.0 | | 0 | 0 | 6 | 13.2 | 0.5 | 2 | 7.9 | | |
| | | No. of Samples | 5 | | 5 | 2 | 2 | 1 | 1 | 2 | 2 | | |
| | | | | | | | | | | | | | |
| | 4.0 | Average | (Median) 430 | 24 | 1 | 0.08 | 14 | 11.9 | 0.9 | 2 | 8.1 | 89 | |
| | | Maximum | >1,500 | 24 | 3 | 0.48 | 24 | 13.3 | 1.2 | 3 | 8.3 | 90 | |
| | | Minimum | < 3.0 | 23 | 0 | 0 | 6 | 10.5 | 0.5 | 1 | 7.9 | 88 | |
| | | No. of Samples | 5 | 4 | 5 | 6 | 4 | 2 | 2 | 6 | 4 | 4 | |
| | | | | | | | | | | | | | |
| | 5.0 | Average | (Median) 310 | | 0 | | | | | | | | |
| | | Maximum | 1,100 | | 0 | | | | | | | | |
| | | Minimum | 75 | | 0 | | | | | | | | |
| | | No. of Samples | 4 | | 4 | | | | | | | | |
| | | | | | | | | | | | | | |
| | 6.0 | Average | (Median) 240 | 24 | 1 | 0.11 | 10 | 12.0 | 0.9 | 2 | 8.0 | 89 | |
| | | Maximum | 1,100 | 24 | 3 | 0.44 | 16 | 13.3 | 1.0 | 3 | 8.1 | 90 | |
| | | Minimum | 3.6 | 23 | 0 | 0 | 5 | 10.6 | 0.7 | 1 | 7.9 | 88 | |
| | | No. of Samples | 5 | 2 | 5 | 4 | 3 | 2 | 2 | 4 | 3 | 2 | |
| | | | | | | | | | | | | | |
| | 7.0 | Average | (Median) 23 | 24 | 0 | 0 | 16 | 11.7 | 1.7 | 1 | 7.9 | 90 | |
| | | Maximum | 460 | 24 | 0 | 0 | 16 | 11.7 | 1.7 | 1 | 7.9 | 90 | |
| | | Minimum | 23 | 24 | 0 | 0 | 16 | 11.7 | 1.7 | 1 | 7.9 | 90 | |
| | | No. of Samples | 3 | 1 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| | | | | | | | | | | | | | |
| | 8.0 | Average | (Median) 80 | 24 | 0 | 0.11 | 13 | 13.4 | 0.4 | 2 | 8.2 | 89 | |
| | | Maximum | > 1,100 | 24 | Trace | 0.44 | 24 | 13.4 | 0.4 | 3 | 8.5 | 90 | |
| | | Minimum | < 3.0 | 23 | 0 | 0 | 6 | 13.4 | 0.4 | 1 | 7.9 | 88 | |
| | | No. of Samples | 4 | 2 | 4 | 4 | 3 | 1 | 1 | 4 | 3 | 2 | |

## Table 20 - SUMMARY OF AVERAGE ANALYTICAL RESULTS - LAKE ONTARIO (Cont'd)

| Sampling Range and Location | Station (Miles) | | Coliforms M.P.N. per 100ml | Chlorides ppm | Phenols ppb | Ammonia as $N_2$ ppm | Temp. °C | D.O. ppm | B.O.D. 5 Day ppm | Turbidity ppm | pH | Alkalinity ppm | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OC (Cont'd) | 10.0 | Average | (Median) 43 | | 0 | 0.15 | 8 | 13.5 | 0.8 | 3 | 8.0 | | |
| | | Maximum | 240 | | Trace | 0.30 | 10 | 13.5 | 0.8 | 4 | 8.2 | | |
| | | Minimum | 3.6 | | 0 | 0 | 6 | 13.5 | 0.8 | 1 | 7.7 | | |
| | | No. of Samples | 3 | | 3 | 2 | 2 | 1 | 1 | 2 | 2 | | |
| OE A range easterly from point "O" on a bearing of N 75°E | 0.5 | | | | | | | | | | | | |
| | | Average | (Median) 43 | 20 | 1 | 0 | 21 | 12.2 | 1.1 | 3 | 8.5 | 95 | |
| | | Maximum | 1,500 | 22 | 6 | Trace | 23 | 12.2 | 1.1 | 4 | 8.6 | 96 | |
| | | Minimum | < 3.0 | 19 | 0 | 0 | 16 | 12.2 | 1.1 | 2 | 8.4 | 94 | |
| | | No. of Samples | 16 | 4 | 14 | 4 | 5 | 1 | 1 | 5 | 5 | 3 | |
| | 1.0 | | | | | | | | | | | | |
| | | Average | (Median) 23 | 22 | 1 | 0.08 | 19 | 11.3 | 1.6 | 3 | 8.3 | 91 | |
| | | Maximum | 1,100 | 24 | 6 | 0.36 | 23 | 12.5 | 2.1 | 4 | 8.5 | 95 | |
| | | Minimum | 3.6 | 19 | 0 | 0 | 12 | 10.6 | 1.1 | 1 | 8.0 | 88 | |
| | | No. of Samples | 17 | 8 | 18 | 8 | 7 | 3 | 5 | 9 | 9 | 7 | |
| | 1.5 | | | | | | | | | | | | |
| | | Average | (Median) 48 | 20 | 0 | 0 | 22 | | | 2 | 8.5 | 95 | |
| | | Maximum | 93 | 20 | 0 | 0 | 23 | | | 2 | 8.5 | 96 | |
| | | Minimum | 3.6 | 19 | 0 | 0 | 22 | | | 2 | 8.4 | 94 | |
| | | No. of Samples | 4 | 4 | 4 | 3 | 4 | | | 4 | 4 | 3 | |
| | 2.0 | | | | | | | | | | | | |
| | | Average | (Median) 43 | 22 | 1 | 0 | 20 | 11.6 | 1.1 | 3 | 8.3 | 94 | |
| | | Maximum | 1,100 | 27 | 6 | Trace | 23 | 11.6 | 1.5 | 4 | 8.5 | 96 | |
| | | Minimum | < 3.6 | 20 | 0 | 0 | 14 | 11.5 | 0.2 | 1 | 8.0 | 88 | |
| | | No. of Samples | 17 | 10 | 15 | 7 | 10 | 2 | 6 | 12 | 10 | 10 | |
| | 3.0 | | | | | | | | | | | | |
| | | Average | (Median) 23 | 21 | 1 | 0.09 | 21 | 12.2 | 1.2 | 3 | 8.4 | 93 | |
| | | Maximum | 1,100 | 24 | 6 | 0.26 | 23 | 12.9 | 1.6 | 6 | 8.6 | 96 | |
| | | Minimum | 3.6 | 20 | 0 | 0 | 16 | 11.5 | 0.8 | 2 | 8.1 | 88 | |
| | | No. of Samples | 17 | 5 | 16 | 6 | 5 | 2 | 3 | 7 | 7 | 5 | |
| | 4.0 | | | | | | | | | | | | |
| | | Average | (Median) 23 | 22 | 1 | 0 | 20 | 11.6 | 1.5 | 3 | 8.3 | 93 | |
| | | Maximum | 1,100 | 25 | 6 | 0.02 | 23 | 12.6 | 4.3 | 6 | 8.5 | 96 | |
| | | Minimum | < 3.0 | 17 | 0 | 0 | 13.5 | 10.8 | 0 | 1 | 7.9 | 90 | |
| | | No. of Samples | 17 | 13 | 15 | 8 | 13 | 4 | 9 | 15 | 13 | 13 | |
| | 5.0 | | | | | | | | | | | | |
| | | Average | (Median) 120 | | 0 | | | | | | | | |
| | | Maximum | 150 | | Trace | | | | | | | | |
| | | Minimum | 43 | | 0 | | | | | | | | |
| | | No. of Samples | 4 | | 4 | | | | | | | | |
| | 6.0 | | | | | | | | | | | | |
| | | Average | (Median) 75 | 23 | Trace | 0 | 15 | 11.4 | 1.0 | 2 | 8.0 | 90 | |
| | | Maximum | 93 | 23 | Trace | 0 | 16 | 12.0 | 1.1 | 3 | 8.0 | 92 | |
| | | Minimum | 9.1 | 23 | 0 | 0 | 13 | 10.8 | 0.9 | 1 | 7.9 | 88 | |
| | | No. of Samples | 3 | 4 | 3 | 4 | 2 | 2 | 2 | 4 | 2 | 4 | |

Table 20 - SUMMARY OF AVERAGE ANALYTICAL RESULTS - LAKE ONTARIO (Cont'd)

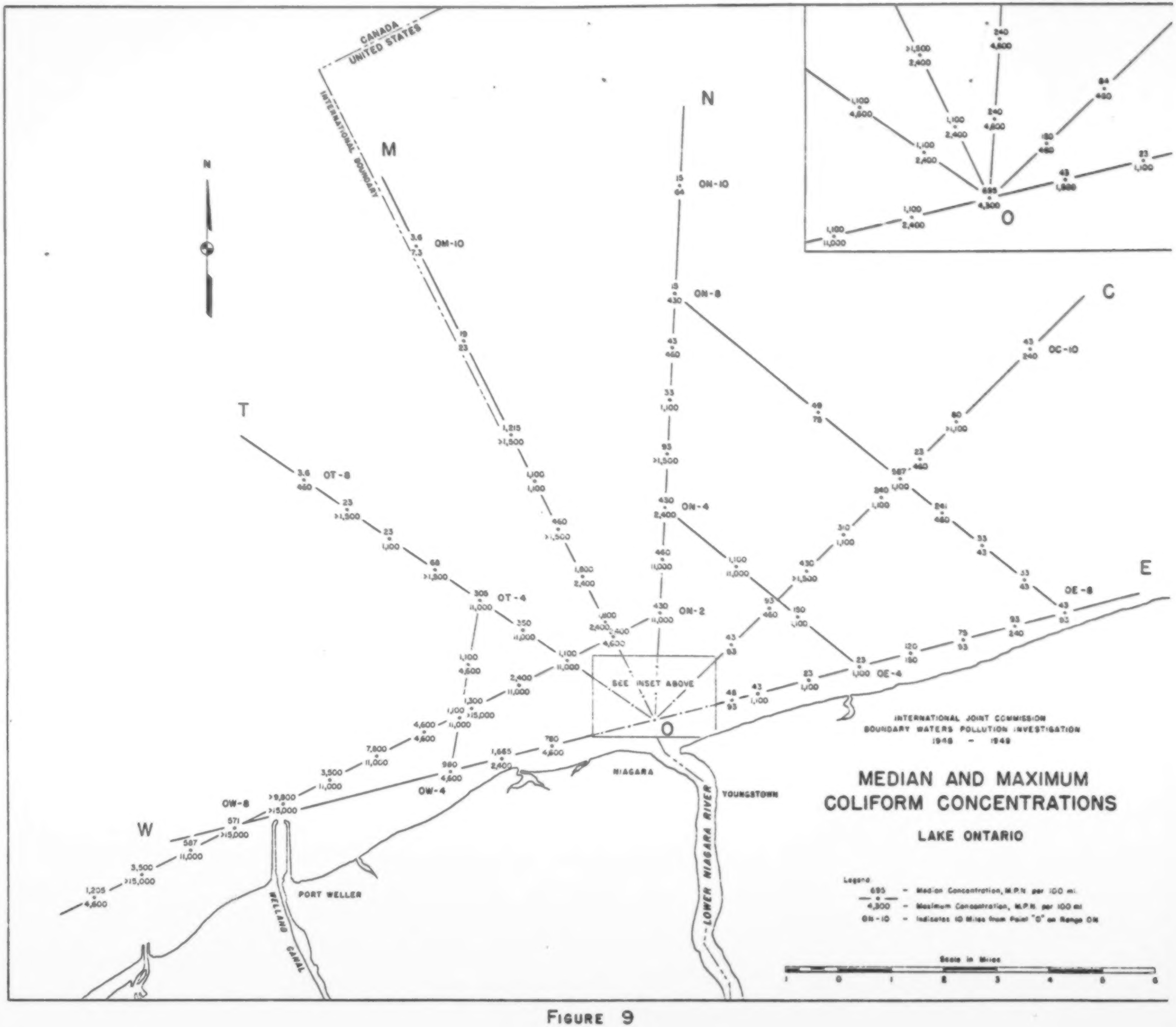
| Sampling Range and Location | Station (Miles) | | Coliforms M.P.N. per 100ml | Chlorides ppm | Phenols ppb | Ammonia as $N_2$ ppm | Temp. °C | D.O. ppm | B.O.D. 5 Day ppm | Turbidity ppm | pH | Alkalinity ppm | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OE (Cont'd) | 7.0 | Average | (Median) 93 | | 0 | | | | | | | | |
| | | Maximum | 240 | | Trace | | | | | | | | |
| | | Minimum | 23 | | 0 | | | | | | | | |
| | | No. of Samples | 3 | | 3 | | | | | | | | |
| | | | | | | | | | | | | | |
| | 8.0 | Average | (Median) 43 | 23 | Trace | 0 | 13 | 11.9 | 0.4 | 2 | 8.0 | 90 | |
| | | Maximum | 93 | 24 | Trace | 0 | 13 | 11.9 | 0.4 | 2 | 8.0 | 92 | |
| | | Minimum | 9.1 | 22 | 0 | 0 | 13 | 11.9 | 0.4 | 2 | 8.0 | 88 | |
| | | No. of Samples | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 3 | 1 | 3 | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| OW-4 - OT-4<br>A range from mile 4 on Range OW to mile 4 on Range OT | 1.0 | Average | (Median) 1,100 | 22 | 1 | 0.15 | 19 | 11.8 | 2.1 | 4 | 8.2 | 94 | |
| | | Maximum | 11,000 | 24 | 7 | 0.44 | 24 | 11.8 | 2.6 | 7 | 8.4 | 95 | |
| | | Minimum | 23 | 20 | 0 | 0 | 13 | 11.8 | 1.6 | 1 | 7.9 | 92 | |
| | | No. of Samples | 9 | 3 | 9 | 3 | 2 | 1 | 2 | 4 | 4 | 3 | |
| | | | | | | | | | | | | | |
| | 2.0 | Average | (Median) 1,100 | 23 | 1 | Trace | 21 | 11.9 | 1.3 | 2 | 8.3 | 93 | |
| | | Maximum | 4,600 | 25 | 6 | Trace | 24 | 11.9 | 2.0 | 3 | 8.4 | 96 | |
| | | Minimum | 15 | 21 | 0 | Trace | 13 | 11.9 | 0.6 | 1 | 8.3 | 88 | |
| | | No. of Samples | 9 | 3 | 7 | 1 | 4 | 1 | 2 | 4 | 4 | 3 | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| OE-4 - ON-4<br>A range from mile 4 on Range OE to mile 4 on Range ON | 1.5 | Average | (Median) 150 | 22 | 1 | 0.12 | 21 | 11.0 | 1.1 | 3 | 8.3 | 93 | |
| | | Maximum | 1,100 | 25 | 6 | 0.48 | 23 | 11.0 | 1.4 | 6 | 8.5 | 96 | |
| | | Minimum | 3.6 | 20 | 0 | 0 | 16 | 11.0 | 0.8 | 2 | 7.9 | 88 | |
| | | No. of Samples | 13 | 5 | 13 | 6 | 5 | 1 | 3 | 7 | 7 | 5 | |
| | | | | | | | | | | | | | |
| | 3.0 | Average | (Median) 1,100 | 20 | 2 | 0 | 21 | 11.1 | 1.2 | 3 | 8.4 | 95 | |
| | | Maximum | 11,000 | 20 | 12 | 0 | 23 | 11.1 | 1.2 | 4 | 8.5 | 96 | |
| | | Minimum | 3 | 20 | 0 | 0 | 16 | 11.1 | 1.2 | 2 | 8.4 | 94 | |
| | | No. of Samples | 13 | 3 | 11 | 4 | 5 | 1 | 1 | 5 | 5 | 3 | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| OE-8 - ON-8<br>A range from mile 8 on Range OE to mile 8 on Range ON | 1.0 | Average | (Median) 33 | | 0 | | | | | | | | |
| | | Maximum | 43 | | 0 | | | | | | | | |
| | | Minimum | 23 | | 0 | | | | | | | | |
| | | No. of Samples | 2 | | 2 | | | | | | | | |
| | | | | | | | | | | | | | |
| | 2.0 | Average | (Median) 33 | 24 | 4 | 0 | | | | 2 | | 90 | |
| | | Maximum | 43 | 24 | 8 | 0 | | | | 2 | | 90 | |
| | | Minimum | 23 | 24 | 0 | 0 | | | | 2 | | 90 | |
| | | No. of Samples | 2 | 1 | 2 | 1 | | | | 1 | | 1 | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |

## Table 20 - SUMMARY OF AVERAGE ANALYTICAL RESULTS - LAKE ONTARIO (Cont'd)

| Sampling Range and Location | Station (Miles) | | Coliforms M.P.N. per 100ml. | Chlorides ppm | Phenols ppb | Ammonia as $N_2$ ppm | Temp °C | D.O. ppm | B.O.D. 5 Day ppm | Turbidity ppm | pH | Alkalinity ppm | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OW-8 - OW-8 (Cont'd) | 3.0 | Average | (Median) 241 | | 0 | | | | | | | | |
| | | Maximum | 460 | | 0 | | | | | | | | |
| | | Minimum | 23 | | 0 | | | | | | | | |
| | | No. of Samples | 2 | | 2 | | | | | | | | |
| | 4.0 | Average | (Median) 587 | 23 | 0 | 0 | 13 | 11.8 | 0.9 | 2 | 8.0 | 91 | |
| | | Maximum | 1,100 | 23 | 0 | 0 | 13 | 11.8 | 0.9 | 2 | 8.0 | 92 | |
| | | Minimum | 75 | 23 | 0 | 0 | 13 | 11.8 | 0.9 | 2 | 8.0 | 90 | |
| | | No. of Samples | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 2 | 1 | 2 | |
| | 6.0 | Average | (Median) 49 | | Trace | | | | | | | | |
| | | Maximum | 75 | | Trace | | | | | | | | |
| | | Minimum | 23 | | 0 | | | | | | | | |
| | | No. of Samples | 2 | | 2 | | | | | | | | |
| OW-2 thru OW-8<br>A range having its zero mileage at mile 2 on Range OW and extended westward thru mile 8 on Range OW for a distance of 12 miles | 1.0 | Average | (Median) 2,400 | | Trace | | | | | | | | |
| | | Maximum | 4,600 | | Trace | | | | | | | | |
| | | Minimum | 460 | | 0 | | | | | | | | |
| | | No. of Samples | 5 | | 3 | | | | | | | | |
| | 1.1 | | INTERNATIONAL BOUNDARY | | | | | | | | | | |
| | 2.0 | | This point coincides with sampling point OW- 2. | | | | | | | | | | |
| | | | Results are included with those for OT- 2. | | | | | | | | | | |
| | 3.0 | Average | (Median) 2,400 | | 0 | | | | | | | | |
| | | Maximum | 11,000 | | 0 | | | | | | | | |
| | | Minimum | 1,100 | | 0 | | | | | | | | |
| | | No. of Samples | 5 | | 3 | | | | | | | | |
| | 4.0 | Average | (Median) 1,300 | | 0 | | | | | | | | |
| | | Maximum | > 15,000 | | 0 | | | | | | | | |
| | | Minimum | 1,100 | | 0 | | | | | | | | |
| | | No. of Samples | 4 | | 3 | | | | | | | | |
| | 5.0 | Average | (Median) 4,600 | | 0 | | | | | | | | |
| | | Maximum | 4,600 | | 0 | | | | | | | | |
| | | Minimum | 460 | | 0 | | | | | | | | |
| | | No. of Samples | 4 | | 3 | | | | | | | | |
| | 6.0 | Average | (Median) 7,800 | 24 | 0 | 0 | 20 | | | 1 | 8.3 | 93 | |
| | | Maximum | 11,000 | 25 | Trace | 0 | 21 | | | 2 | 8.5 | 94 | |
| | | Minimum | 460 | 23 | 0 | 0 | 20 | | | 1 | 8.1 | 92 | |
| | | No. of Samples | 4 | 4 | 4 | 4 | 4 | | | 4 | 4 | 4 | |

Table 20 - SUMMARY OF AVERAGE ANALYTICAL RESULTS - LAKE ONTARIO (Cont'd)

| Sampling Range and Location | Station (Miles) | | Coliforms M.P.N. per 100ml. | Chlorides ppm | Phenols ppb | Ammonia as $N_2$ ppm | Temp. °C | D.O. ppm | B.O.D. 5 Day ppm | Turbidity ppm | pH | Alkalinity ppm | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GN-2 thru GN-8<br>(Cont'd) | 7.0 | Average | (Median)<br>3,500 | | Trace | | | | | | | | |
| | | Maximum | 11,000 | | Trace | | | | | | | | |
| | | Minimum | 1,100 | | 0 | | | | | | | | |
| | | No. of Samples | 4 | | 3 | | | | | | | | |
| | 8.0 | Average | (Median)<br>> 9,500 | | 0 | | | | | | | | |
| | | Maximum | > 15,000 | | Trace | | | | | | | | |
| | | Minimum | 43 | | 0 | | | | | | | | |
| | | No. of Samples | 4 | | 4 | | | | | | | | |
| | 9.0 | Average | (Median)<br>871 | | 0 | | | | | | | | |
| | | Maximum | > 15,000 | | Trace | | | | | | | | |
| | | Minimum | 3.6 | | 0 | | | | | | | | |
| | | No. of Samples | 4 | | 3 | | | | | | | | |
| | 10.0 | Average | (Median)<br>587 | | 0 | | | | | | | | |
| | | Maximum | 11,000 | | Trace | | | | | | | | |
| | | Minimum | 23 | | 0 | | | | | | | | |
| | | No. of Samples | 4 | | 4 | | | | | | | | |
| | 11.0 | Average | (Median)<br>3,500 | | Trace | | | | | | | | |
| | | Maximum | > 15,000 | | Trace | | | | | | | | |
| | | Minimum | 3.0 | | 0 | | | | | | | | |
| | | No. of Samples | 4 | | 4 | | | | | | | | |
| | 12.0 | Average | (Median)<br>1,205 | 24 | 3 | 0 | 21 | | | 2 | 8.2 | 92 | |
| | | Maximum | 4,600 | 25 | 6 | 0 | 21 | | | 2 | 8.4 | 94 | |
| | | Minimum | < 3.0 | 23 | 0 | 0 | 20 | | | 1 | 8.1 | 88 | |
| | | No. of Samples | 4 | 4 | 4 | 4 | 4 | | | 4 | 4 | 4 | |



INTERNATIONAL JOINT COMMISSION
BOUNDARY WATERS POLLUTION INVESTIGATION
1946 - 1949

MEDIAN AND MAXIMUM
COLIFORM CONCENTRATIONS

LAKE ONTARIO

Legend
695 - Median Concentration, M.P.N. per 100 ml.
4,300 - Maximum Concentration, M.P.N. per 100 ml
ON-10 - Indicates 10 Miles from Point "O" on Range ON
Scale in Miles
1 0 1 2 3 4 5 6
N
M
T
W
E
C
O
CANADA
UNITED STATES
INTERNATIONAL BOUNDARY
ON-10
ON-8
ON-4
ON-2
OM-10
OT-8
OT-4
OW-4
OW-8
OC-10
OE-8
OE-4
SEE INSET ABOVE
NIAGARA
YOUNGSTOWN
LOWER NIAGARA RIVER
PORT WELLER
WELLAND CANAL
15 64
15 430
43 460
33 1,100
93 >1,500
430 2,400
460 11,000
430 11,000
3.6 7.3
19 23
1,215 >1,500
1,100 1,100
460 >1,500
1,800 2,400
1,800 2,400
2,400 4,600
3.6 460
23 >1,500
23 1,100
68 >1,500
306 11,000
350 11,000
1,100 11,000
1,100 4,600
2,400 11,000
1,300 >15,000
1,100 11,000
4,600 4,600
7,800 11,000
3,500 11,000
>9,800 >15,000
571 >15,000
587 11,000
3,500 >15,000
1,205 4,600
780 4,600
1,665 2,400
980 4,600
48 93
43 1,100
23 1,100
23 1,100
120 150
75 93
93 240
43 93
43 93
150 1,100
93 460
430 >1,500
310 1,100
240 1,100
587 1,100
23 460
60 >1,100
43 240
49 79
1,100 11,000
241 460
33 43
33 43
695 4,300
1,100 11,000
1,100 2,400
1,100 4,600
1,100 2,400
>1,500 2,400
1,100 2,400
240 4,600
240 4,600
150 460
84 460
43 1,566
23 1,100

FIGURE 9

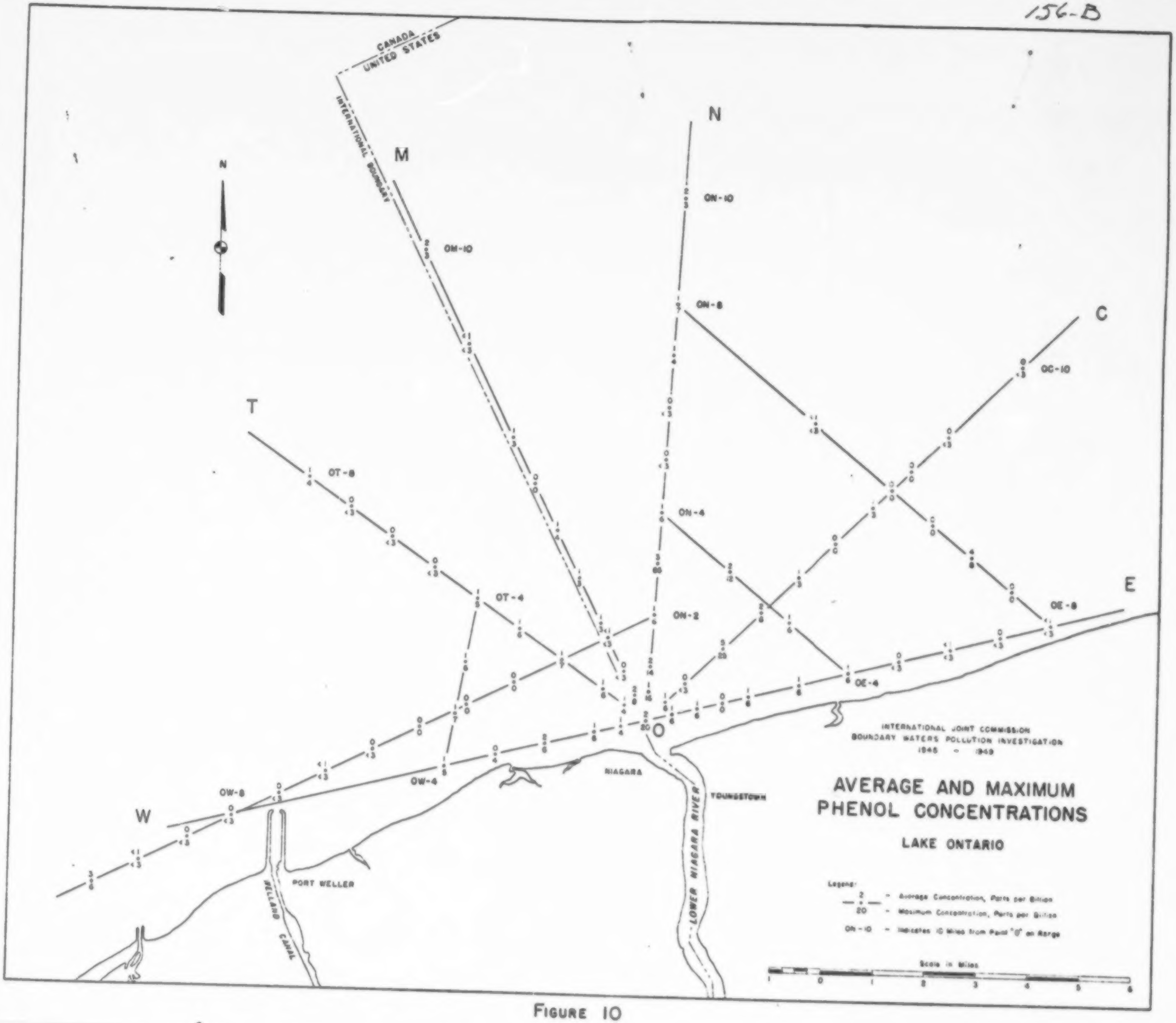

INTERNATIONAL JOINT COMMISSION
BOUNDARY WATERS POLLUTION INVESTIGATION
1946 - 1949
AVERAGE AND MAXIMUM
PHENOL CONCENTRATIONS
LAKE ONTARIO
Legend:
2 = Average Concentration, Parts per Billion
20 = Maximum Concentration, Parts per Billion
ON-10 = Indicates 10 Miles from Point "O" on Range
Scale in Miles
1
0
1
2
3
4
5
6
N
CANADA
UNITED STATES
INTERNATIONAL BOUNDARY
M
N
C
T
E
W
OM-10
ON-10
ON-8
OC-10
OT-8
ON-4
OT-4
ON-2
OE-8
OE-4
O
OW-8
OW-4
NIAGARA
YOUNGSTOWN
LOWER NIAGARA RIVER
PORT WELLER
WELLAND CANAL

FIGURE 10

## COMPARISONS - 1913 and 1948-1949 RESULTS

Many sampling ranges on the upper and lower Niagara River were common to both the 1913 and the present investigations. Therefore, it is possible to compare the conditions then and now. However, it is difficult to compare the lake data of the two investigations because of the paucity of corresponding sampling points in Lake Erie and Lake Ontario. Since the previous examination was essentially a bacteriological one, it is only possible to compare the coliform results. Table 21 records the results of the two investigations at corresponding sampling points in these waters. These comparisons can be approximate only since averages were used in the 1913 results and medians in the present. The former tends to give greater weight to abnormal results. Furthermore, the 1913 results are probably high because the tests were "presumptive" only. The B. coli index of the 1913 results has been changed to the M.P.N. index by applying a factor of 2.4 to the former.

Table 21 - AVERAGE COLIFORM RESULTS, 1913 and 1948-1949

| Stream | Location and Range | M.P.N. per 100 ml. | |
|---|---|---|---|
| | | 1913 Average* | 1948-1949 Median* |
| **Lake Erie** | **Main Body** | < 5 | < 10 |
| | Buffalo Outer Harbor | | |
| | Range BA - Breakwater | 50 | 120 |
| | Range FH - Breakwater | 79 | 120 |
| | Range UL - 1,000' from shore | 1,340 | 1,900 |
| Upper Niagara River | Buffalo Intake (Ni-37.7) | 0.7 | 3.6 |
| | Bird Island Ferry Dock (Ni-35.2) | | |
| | United States Side | 3,100 | 150 |
| | International Boundary | 14 | 3.6 |
| | Canadian Side | 13.5 | 23 |
| | International Bridge (Ni-34.3) | | |
| | United States Side | 29,600 | 2,400 |
| | International Boundary | 6.2 | 430 |
| | Canadian Side | 19.7 | 23 |
| | Strawberry Island (Ni-32.5) | | |
| | Head of Island | 24 | 8.2 |
| | International Boundary | 1.0 | 9.1 |
| | Canadian Side | 210 | 30 |

Table 21 — AVERAGE COLIFORM RESULTS, 1913 AND 1948-1949 (Continued)

| Stream | Location and Range | M.P.N. per 100 ml. | |
|---|---|---|---|
| | | 1913 Average* | 1948-1949 Median* |
| Upper Niagara River (Cont'd) | South Grand Island Bridge (Ni-29.0) | | |
| | United States Side | 12,700 | 3,900 |
| | Grand Island Side | 9.6 | 31 |
| | North Grand Island Bridge (Ni-19.3) | | |
| | United States Side | 50,000 | 9,300 |
| | Center of East Channel | 15,600 | 930 |
| | Grand Island Side | 615 | 43 |
| | Beaver Island State Park (Ni-26.7) | | |
| | Grand Island Side | 7.2 | 9.1 |
| | Canadian Side | 7.2 | 445 |
| | Navy Island (Ni-20.0) | | |
| | Navy Island Side | 84 | 23 |
| | Canadian Side | 94 | 190 |
| | International Branch (Ni-19.4) | | |
| | Grand Island Side | 700 | 23 |
| | International Boundary | 87 | 19 |
| Lower Niagara River | Lewiston Bridge (Ni-8.0) | | |
| | United States Side | 1,890 | 2,400 |
| | International Boundary | 7,260 | 2,400 |
| | Canadian Side | 756 | 2,400 |
| | Above Youngstown (Ni-2.4) | | |
| | United States Side | 45,200 | 2,400 |
| | International Boundary | 42,500 | 2,300 |
| | Canadian Side | 14,780 | 2,300 |
| | Outlet of River (Ni-1.0) | | |
| | United States Side | 11,600 | 2,300 |
| | International Boundary | 57,600 | 4,300 |
| | Canadian Side | 31,600 | 2,400 |
| Lake Ontario | Point "O" | 15,360 | 695 |
| | On OT. 1 mile from Point "O" | 3,240 | 1,100 |
| | On OC. 1 mile from Point "O" | 10,200 | 84 |
| | On OE. 1 mile from Point "O" | 1,400 | 23 |
| | On OW-4 - OT-4. 2 miles from OW-4 | 132 | 1,100 |
| | On OM. 2 miles from Point "O" | 1,510 | 1,800 |
| | On ON. 2 miles from Point "O" | 2,500 | 430 |
| | On OC. 2 miles from Point "O" | 910 | 43 |
| | On OT. 7 miles from Point "O" | 18 | 23 |
| | On OM. 10 miles from Point "O" | 9.6 | 3.6 |
| | On OC. 10 miles from Point "O" | 74.5 | 43 |

* These comparisons must be considered as approximate only.

This table indicates that the bacterial pollution of the main body of Lake Erie is the same as in 1913. However, the load in the upper Niagara River on the United States side shows a marked reduction. The sewage treatment plants placed in operation since 1913 are responsible for this reduction in bacterial pollution. The construction of trunk sewers has altered the points of discharge. The pollution along the Canadian shore in the upper river is slightly higher than that shown in the earlier investigation. A substantial coliform reduction is noted in the lower Niagara River. The pollution load at the present time is shown to be uniform, whereas the 1913 average results were somewhat erratic. This same reduction is reflected in Lake Ontario within an area of about two miles from the outlet of the Niagara River.

## SUPPLEMENTARY INFORMATION ON POLLUTION EFFECTS

In addition to the effect of pollution on these boundary waters shown by the analytical results of samples collected during the survey, supplementary material has been obtained from various sources and from special studies. This information has been compiled in a further effort to evaluate the effects of pollution.

### Transboundary Movement of Pollution

The Treaty of 1909 between the two countries stated that "the boundary waters and waters flowing across the boundary shall not be polluted on either side to the injury of health or property on the other." An answer was therefore sought as to whether transboundary pollution was taking place, to what extent, and in what localities. The information utilized in answering these questions was obtained from the analytical results, float studies, and a review of the data from various sources.

In Lake Erie, the general trend of both coliform and phenol results indicates that major pollution is normally confined to a relatively narrow path along the United States shore. However, certain high phenol results along the Canadian shore, together with the movement of a number of floats from either side to the other, suggest that transboundary currents may prevail during periods of abnormal meteorological conditions. An undertow along the east shore of Lake Erie, for example, such as accompanies heavy southwesterly winds or a seiche, would tend to spread the pollution introduced along the United States shore into the main body of Lake Erie toward the International Boundary. That this does occur is evidenced by the widening of the zone of pollution during such storm periods.

The spread of pollution across the boundary in the upper Niagara River is restricted by the high velocity of flow. The analytical results indicate that normally the pollution zone along the eastern shore is confined within United States waters and consequently to the East Channel of the river. The westerly portion of the river is influenced, however, by storm conditions in Lake Erie which affect the quality of the main body of the lake. Ice jams along the river and strong winds may alter normal flow conditions but there is no record of the West Channel of the river being affected by the polluted zone along the United States shore. This is substantiated by the analytical results.

In the lower Niagara River, cross-currents in the rapids and Whirlpool effect a thorough mixing of waters. Analyses of the water show that pollution is uniformly dispersed across each range along the lower river. Thus, pollution is transferred across the boundary, while at the same time, the full diluting capacity of the river is afforded.

The effect of the pollution persists into Lake Ontario for some 8 to 10 miles from the river outlet, and there is no pronounced tendency of flow from either side of the boundary to the other.

## Municipal Water Supplies

The public health hazard or burden placed by pollution on the public water supplies of the communities bordering on the boundary waters was evaluated during this investigation. Special studies involving the sampling and analysis of the raw waters at the purification plants were undertaken by the field staffs, the results being summarized in table 22. The water supplies are located in the upper Niagara River except for one near the United States side of Lake Erie and another near the Canadian side at the outlet of the lower river. The operating records of the major treatment plants were also reviewed. These studies show the local conditions at each plant as well as the progressive changes in water quality along the Niagara River.

In general, the analytical results for supplies located in United States waters show similar characteristics in that the median and average values indicated a moderate pollution, whereas the maximum or peak values were indicative of heavy pollution. These characteristics exist due to the precarious locations of the river intakes near the edge of the normal pollution zone and of the Western New York Water Company's intake near the dumping grounds in Lake Erie. During periods of unusual flow this pollution zone widens, and the intakes are thus subjected to sporadic slugs of heavy pollution. For instance, maximum coliform M.P.N. values of, or greater than, 11,000 per 100 ml. were found at the Lake Erie intake of the Western New York Water

Company, at the Tonawandas, and at the Niagara Falls No. 1 plant. Similarly, maximum phenols as high as 80 p.p.b. were found at these plants. These peak values are reflected in the maximum chlorine demand results which range up to 1.1 p.p.m. The wide and rather rapid changes in the character and intensity of polluting substances in the raw water have adversely influenced the purification problem. A sudden increase in pollution of the raw water results in a similarly sudden increase of the chlorine required for disinfection. The erratic chlorine demands experienced at these supplies are a continual hazard to public health. For these reasons, the New York State Department of Health has recommended that new water supply intakes be located in the waters of the West Channel.

The analytical results for the other two United States supplies do not show the same widely fluctuating quality. The intake for the City of Buffalo is located at the Niagara River inlet near the International Boundary where the raw water is not usually affected by sewage or industrial waste pollution. Plant records for 1949 indicate that the quality of the raw water meets the U. S. Public Health Service bacteriological requirements for a treated water. In contrast, the Niagara Falls No. 2 plant has a shore intake which is subjected to highly polluted water at all times. The M.P.N. coliform values had a median of 3,900 and a maximum of 110,000 per 100 ml., while phenols averaged 31.5 p.p.b. with a maximum of 80 p.p.b.

The supplies located along the Canadian side of the upper river are of uniformly good sanitary quality. The Town of Niagara supply near the mouth of the lower river, however, is markedly affected by pollution. The coliform and phenol results indicate that the operation of this treatment plant is continually handicapped by substantial pollution.

The operating records of the United States plants were reviewed in order to ascertain the changes taking place in the raw water quality over a more extended period. The proper disinfection of the supplies affected by sporadic pollution has been a continuous problem, requiring the rate of chlorine application to be varied in accordance with the degree of the pollution. Water plant records for the last ten years show that on no occasion was a treated water unsafe for human consumption. Notwithstanding, there have been occasions when water plants were unable to cope with rapid and extensive changes in chlorine demand. Such an occurrence in 1933 resulted in an outbreak of water-borne disease at Niagara Falls, New York, affecting approximately ten thousand people.

In addition to the difficulty of disinfection, the records show that taste and odor control has been a major problem in these same waters during the past 20 years. Little success was obtained in this control until the introduction in 1943 of chlorine dioxide treatment, which is now practiced at considerable additional expense at all the United States plants in this Section with the exception of that of Buffalo. While this has markedly reduced the problem, occasional complaints are still received.

## Table 22 - SUMMARY OF ANALYTICAL RESULTS FOR MUNICIPAL INTAKE SAMPLES
## INTERNATIONAL JOINT COMMISSION FIELD DATA - 1948-1949

| Municipal Supply | Mileage Index | | Coliforms M.P.N. per 100ml. | Chlorides ppm | Phenols ppb | Ammonia as $N_2$ ppm | Chlorine Demand ppm | D.O. ppm | B.O.D. 5 Day ppm | Turbidity ppm | pH | Alkalinity ppm | Total Iron ppm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Western New York Water Company, New York | Range 2E, 4,425' from shore | | | | | | | | | | | | |
| | | Average | (Median)<br>75 | 20.6 | 3.4 | 0.02 | 0.45 | | 0.71 | 13.7 | 7.6 | 93 | 0.50 |
| | | Maximum | >11,000 | 25 | 26 | 0.22 | 0.70 | | 3.4 | 47 | 8.4 | 99 | 1.2 |
| | | Minimum | < 3.0 | 18 | 0 | 0 | 0.22 | | 0.1 | 4 | 7.5 | 87 | 0.1 |
| | | No. of Samples | 150 | 24 | 25 | 23 | 23 | | 21 | 24 | 24 | 24 | 16 |
| | | | | | | | | | | | | | |
| City of Buffalo, New York | Ni-37.7 | | | | | | | | | | | | |
| | | Average | (Median)<br>3.6 | 21 | 4 | 0.02 | 0.43 | | 0.37 | 11.7 | 7.8 | 96 | |
| | | Maximum | 460 | 25 | 45 | 0.18 | 0.73 | | 1.0 | 28 | 8.3 | 102 | |
| | | Minimum | < 3.0 | 18 | 0 | 0 | 0.23 | | 0.1 | 4 | 7.3 | 91 | |
| | | No. of Samples | 78 | 24 | 26 | 23 | 23 | | 22 | 25 | 25 | 24 | |
| | | | | | | | | | | | | | |
| Town of Fort Erie, Ontario (Upper Plant) | Ni-33.2 | | | | | | | | | | | | |
| | | Average | (Median)<br>3.6 | 20 | Trace | | | 12.9 | 0.5 | 11 | 8.2 | 90 | |
| | | Maximum | 15 | 21 | Trace | | | | 1.0 | 26 | 8.4 | 94 | |
| | | Minimum | 3.6 | 18 | 0 | | | | 0.0 | 1 | 7.9 | 86 | |
| | | No. of Samples | 3 | 3 | 3 | | | 1 | 2 | 3 | 3 | 3 | |
| | | | | | | | | | | | | | |
| Town of Fort Erie, Ontario (Lower Plant) | Ni-31.4 | | | | | | | | | | | | |
| | | Average | (Median)<br>2.0 | 19 | 0 | | | 13.3 | 0.9 | 16 | 8.1 | 94 | |
| | | Maximum | 43 | 21 | Trace | | | 13.8 | 1.5 | 28 | 8.4 | 100 | |
| | | Minimum | 2.0 | 17 | 0 | | | 12.8 | 0.1 | 1 | 7.9 | 88 | |
| | | No. of Samples | 5 | 5 | 4 | | | 3 | 4 | 5 | 5 | 5 | |
| | | | | | | | | | | | | | |
| City of Tonawanda, New York | Ni-26.2 | | | | | | | | | | | | |
| | | Average | (Median<br>150 | 20.3 | 5.6 | 0.01 | 0.42 | 10.7 | 0.66 | 13.4 | 7.8 | 95 | |
| | | Maximum | 11,000 | 23 | 80 | 0.16 | 0.80 | | 1.4 | 55 | 8.3 | 102 | |
| | | Minimum | < 3.0 | 17 | 0 | 0 | 0.18 | | 0.1 | 1 | 7.4 | 90 | |
| | | No. of Samples | 96 | 31 | 31 | 31 | 30 | 1 | 28 | 32 | 31 | 31 | |
| | | | | | | | | | | | | | |
| City of North Tonawanda, New York | Ni-25.9 | | | | | | | | | | | | |
| | | Average | (Median)<br>230 | 20.4 | 2.4 | 0.01 | 0.46 | 9.1 | 0.6 | 9.4 | 7.8 | 95 | |
| | | Maximum | 4,600 | 24 | 16 | 0.12 | 0.78 | | 5.8 | 28 | 8.3 | 100 | |
| | | Minimum | 3.6 | 18 | 0 | 0 | 0.23 | | 0.1 | 2 | 7.4 | 90 | |
| | | No. of Samples | 90 | 29 | 30 | 29 | 29 | 1 | 25 | 30 | 30 | 28 | |
| | | | | | | | | | | | | | |
| City of Niagara Falls, New York (Plant No. 1) | Ni-18.7 | | | | | | | | | | | | |
| | | Average | (Median)<br>930 | 20.4 | 7.1 | 0.01 | 0.47 | | 0.57 | 11.8 | 7.7 | 94 | |
| | | Maximum | 11,000 | 23 | 35 | 0.04 | 0.70 | | 1.1 | 38 | 8.0 | 98 | |
| | | Minimum | < 3.0 | 17 | 0 | 0 | 0.18 | | 0.2 | 2 | 7.3 | 89 | |
| | | No. of Samples | 54 | 14 | 16 | 16 | 15 | | 15 | 15 | 16 | 14 | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |

## Table 22 - SUMMARY OF ANALYTICAL RESULTS FOR MUNICIPAL INTAKE SAMPLES
### INTERNATIONAL JOINT COMMISSION FIELD DATA - 1948-1949

| Municipal Supply | Mileage Index | | Coliforms M.P.N. per 100ml. | Chlorides ppm | Phenols ppb | Ammonia as $N_2$ ppm | Chlorine Demand ppm | D.O. ppm | B.O.D. 5 Day ppm | Turbidity ppm | pH | Alkalinity ppm | Total Iron ppm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| City of Niagara Falls, Ontario | Ni-16.6 | Average | (Median) 93 | 20 | 0 | 0.04 | | 13.1 | 1.1 | 17 | 8.0 | 92 | |
| | | Maximum | 2,400 | 22 | 4 | | | 14.0 | 1.9 | 31 | 8.3 | 98 | |
| | | Minimum | 3.6 | 18 | 0 | | | 11.4 | 0.1 | 1 | 7.9 | 88 | |
| | | No. of Samples | 11 | 11 | 10 | 1 | | 9 | 7 | 11 | 11 | 11 | |
| City of Niagara Falls, New York (Plant No. 2) | Ni-16.4 | Average | (Median) 3,900 | 21.2 | 31.5 | 0.34 | 0.55 | 4.6 | 1.4 | 15.4 | 7.6 | 93 | |
| | | Maximum | 110,000 | 24 | 80 | 0.12 | 1.10 | 8.9 | 2.7 | 39 | 8.0 | 99 | |
| | | Minimum | 230 | 17 | Trace | 0 | 0.27 | 0.3 | 0.5 | 2 | 7.3 | 79 | |
| | | No. of Samples | 79 | 26 | 28 | 24 | 26 | 2 | 24 | 26 | 24 | 26 | |
| Town of Niagara, Ontario | Ni-1.9 | Average | (Median) 460 | 22 | 3 | 1.6 | | 15.6 | 1.9 | 20 | 8.0 | 92 | |
| | | Maximum | 2.400 | 28 | 12 | | | 17.8 | 3.5 | 35 | 8.2 | 98 | |
| | | Minimum | 79 | 17 | 0 | | | 13.1 | 0.5 | 6 | 7.9 | 82 | |
| | | No. of Samples | 13 | 13 | 11 | 1 | | 12 | 8 | 12 | 12 | 13 | |

## Municipal Sewage Treatment Plants

Special studies of the Buffalo and the Niagara Falls, New York, sewage treatment plants were conducted by the United States field staff during this investigation. The importance of these plants is apparent in view of the fact that the Buffalo plant serves some 70% of the population along the boundary waters, and the Niagara Falls plant over 10%. The study of the two plants showed in part the quantity and characteristics of the sewage plant effluents, and the efficiencies of treatment as denoted by the reduction in biochemical oxygen demand, suspended solids, and coliform densities. A special study was also made at the Niagara Falls plant to determine the toxicity of the effluent to fish life.

The survey of the Buffalo plant was conducted during a six-day period in May 1949. The plant provides primary treatment with chlorination of the effluent. Dry weather flow is about 113 M.G.D. (U.S.). Based on median M.P.N. coliform values, the effluent contained 43,000 per 100 ml., a reduction of 99% of that in the plant influent. The effluent B.O.D. was 154 p.p.m., representing a reduction of about 18%. The suspended solids concentration in the effluent was reduced about 47% to 104 p.p.m. The phenol content of the plant discharge averaged 77 p.p.b., and the chlorine demand 4.8 p.p.m.

The Niagara Falls treatment works survey was made during a six-day period in January 1949, and was followed by an additional bacteriological study in May 1949. This plant provides grit removal and fine screening, and chlorination during the summer months. The influent flow, which is composed of about 90% industrial wastes, averaged 85 M.G.D. (U.S.) during the survey period. The median M.P.N. coliform values per 100 ml. in the effluent were 90,000 during the January survey and 69,000 during the May survey. The treatment produced a reduction of 90% in coliform content when chlorination was practiced. Suspended solids in the effluent measured 425 p.p.m., a reduction of about 8% from that in the plant influent. The B.O.D. of the effluent was 73 p.p.m., representing a reduction of about 6%. The concentration of phenol averaged 362 p.p.b. and chlorine demand of 14.8 p.p.m.

A special bio-assay study was conducted by the New York State Conservation Department in January and February 1949 on the effluent from the Niagara Falls, New York, sewage treatment plant. The fish used in these experiments were Notropis atherinoides, the common "shiner" of the Niagara River. The maximum concentration of the waste used was a 10% dilution. The results of this study showed that the 10% dilution of the effluent had no toxic effect on the fish. Toxicity determinations with concentrations higher than 10% would not have been significant because of the high dilution available in the Niagara River.

## Fish and Wildfowl

Some seventeen fish kills have been reported in the Lake Erie-Lake Ontario Section during the past 15 years. Three of these kills occurred during November and December of 1937 in the Buffalo harbor area, and were reported by the Buffalo Sewer Authority. The remaining fourteen fish kills occurred between 1943 and 1949 in the Buffalo harbor area and in the upper Niagara River. These latter kills have been investigated and reported by the New York State Conservation Department.

While the relative severity of each of the kills has not been estimated, the causative toxic agent for most of them has been determined. Cyanides are implicated as causing seven of the kills with phenols a contributory factor in two of these cases. A lethal dose of chlorine presumably was the cause of two of the kills, while large concentrations of copper and iron salts possibly caused four other kills. The toxic materials causing the four remaining kills, which include the three in 1937, could not be isolated. A large proportion of the fish destroyed have been minnows, particularly the "lake shiner". However, pike, bass, sunfish, and crayfish have been destroyed in lesser numbers.

The sources of the polluting substances causing these kills have been identified in several instances. Wastes discharged from the industries located on the Buffalo River and in the harbor area have presumably caused ten fish kills in that area. The most frequent toxic agents in these cases have been cyanides and copper and iron salts. In the Tonawanda area six kills have occurred in the Niagara River as follows: an automotive manufacturing company causing three kills due to cyanides, a company employing metal plating operations causing another kill due to cyanides, and a paper company plant apparently causing two kills due to chlorine discharges. The last reported kill occurred in the Niagara River at Niagara Falls, New York, but the causative factors were not determined.

Since the Niagara River is an important gathering point for migratory wildfowl, any pollution causing damage to the fowl is of economic importance. Many birds are killed going over the Falls during a fog or as a result of oil pollution. The heaviest mortality occurs during the period from early November to May. A major kill occurred during the 1948-49 season when a total of about 700 birds was swept over the Falls. Of this number it is estimated that 275 died as a direct result of oil pollution. This information is revealed from autopsies made by the Ontario Department of Lands and Forests on birds collected in the Maid of the Mist pool. The effect of oil on fowl is to destroy the buoyant effect of the protecting plumages, causing over-exposure to the icy waters. The bird is rendered helpless by a floating layer of oil.

While the effects of pollution on the feeding material of wildfowl has not been fully determined, it is believed to play an important role in the physical condition of the birds.

### Effect of Plankton on Water Supplies

A special study was undertaken by the United States field staff in the fall of 1948 to determine if plankton organisms were the cause of certain taste and odor problems encountered in water supplies taken from the Niagara River. It was also desired to learn if the plankton found in the river came from Lake Erie or developed in creek mouths and quiet areas along the shore or in the polluted areas of the river itself.

The effect of pollution on plankton in the Niagara River was not clearly shown. The rate of flow in the river is so high that there is not sufficient time for plankton to attain any significant increase in number while in the river. The tributaries have small volumes of flow in comparison to that of the Niagara River. There was no evidence that significant numbers of taste producing plankton in the tributaries were carried into the Niagara River and, consequently, into the water supplies.

Diatoms were the predominant organisms in all samples including those taken from Lake Erie and Lake Ontario. The most common and characteristic among this group were Asterionella formosa, Tabellaria fenestrata, and Fragilaria crotonensis. These are true plankton which are not found attached to objects or the bottom of the stream. None of the diatoms was found in concentrations sufficient to produce taste in water supplies.

A few specimens of Synura uvella and Uroglenopsis americana (class Chrysophyceae) were found in the quiescent waters of Lake Erie, Lake Ontario, and in a swampy area at the downstream end of Grand Island. These organisms are notorious taste-producers but do not survive in swift water. However, the volatile taste-producing oils from disintegrating cells may, under proper conditions, cause tastes in water supplies. Therefore, their presence in Lake Erie is a potential taste and odor hazard to all water supplies along the Niagara River. Other algae were found in some of the samples taken above the water intakes but their concentrations were never high enough to produce taste.

A heavy concentration of the green algae Cladophora sp. was found in the East Channel above the Niagara Falls, New York, water intakes. While this organism probably does not produce taste independently, it may, in conjunction with certain organic wastes in water, produce objectionable taste. This aspect should be studied further. Cladophora may also be responsible for the periodic clogging of filters at water plants.

Taste and Odor Study - Buffalo River

A special study of tastes and odors of the Buffalo River water was conducted by the United States field staff in April 1949. The preliminary work included taking samples at the mouth of the river at its confluence with Buffalo Harbor and the Niagara River. Further studies were made at ranges 3.5 miles (Range NiBu - 41.3) and 5.1 miles (Range NiBu - 42.9) upstream from the mouth of the river.

The study showed that the Buffalo River at its confluence with the Niagara River contains definite taste and odor producing substances. Daily phenol analyses indicated that the river is subjected to slugs of phenolic type wastes. All samples at this location had a predominantly medicinal or iodoform taste. Since the tastes were more pronounced when the phenol content of the river was high, it may be assumed that at least part of the disagreeable tastes were due to phenolic type wastes.

Samples taken daily at Range NiBu - 42.9 presented an odor that was described as petroleum, gasoline or kerosene, and which was not affected by chlorination. It was found that breakpoint chlorination curves followed a rather regular pattern with corresponding relationships in the taste dilution curves. It was not found, however, that a definite relationship existed between the threshold taste and the phenol content of the samples.

The odor of the samples from Range NiBu - 41.3 was described as the same as from Range NiBu - 42.9, although a faint odor of nitrobenzene was detected when the sample was heated. Breakpoint chlorination curves did not exhibit the same characteristics as those from Range NiBu - 42.9, but displayed a chlorine absorption pattern followed by a sharp rise in chlorine residual.

# CHAPTER IX

## DISCUSSION OF FINDINGS AND REMEDIAL MEASURES

> "When there is trouble there is need for
> someone to act as well as advise."
>
> \- Aesop

Data presented in this report show the results of the investigation of pollution in the Lake Erie-Lake Ontario Section of the boundary waters. They indicate, in accordance with the terms of reference to the Commission, the extent, nature and sources of pollution, and in what localities such pollution occurs. The Board has examined and evaluated these various data. From this analysis certain conclusions have been reached, and remedial measures have been determined. The findings and conclusions are discussed herewith.

Canada and the United States jointly possess an unparalleled natural resource in the boundary waters. They constitute the largest body of fresh water in the world and are subject to a multiplicity of uses. Because they vitally affect the health, economy and recreation of both countries it is essential that the waters be so safeguarded from pollution that their use will be in the highest public interests. The importance attached to maintaining these waters in an unpolluted state is evident in the action taken by the two governments, on two separate occasions, in requesting that the International Joint Commission make an investigation of pollution.

## THE 1913 INVESTIGATION

The pollution problem in 1913 was materially different from that of today. The earlier investigation was concerned solely with bacterial pollution from domestic sewage. The industrial processes then in use did not discharge waste products in sufficient quantities to affect seriously the conditions of the waters.

As noted in chapter VIII certain areas of the Niagara River were found seriously polluted in 1913. Except for two septic tank-contact bed treatment units at Lackawanna, New York, and a third septic tank unit at Bridgeburg, Ontario (now the Town of Fort Erie), no sewage treatment installations were then in operation. Thus the raw sewage from nearly 540,000 people was discharged directly through many outlets to these boundary waters and their tributaries. Garbage and other refuse were also dumped into the Niagara River by the City of Niagara Falls, New York. All municipalities obtained their drinking water supplies from the river above their own immediate sewer outfalls. Several of these communities used the water untreated, while others used chlorination as the only protection against water-borne diseases. The two Niagara Falls, New York, supplies were the only ones receiving filtration.

The International Joint Commission, following the 1913 investigation, recommended to the two governments that, for the boundary waters as a whole,

> "It is feasible and practicable, without imposing an unreasonable burden upon the offending communities, to prevent or remedy pollution, both in the case of boundary waters and waters crossing the boundary.

"(a) In the case of city sewage, this can best be accomplished by the installation of suitable collecting and treatment works, the latter having special reference to the removal of bacteria and matters in suspension.

"(b) In the case of vessel sewage, a feasible and inexpensive remedy lies in the employment of recognized methods of disinfection before it is discharged. In the case of water ballast suitable rules and regulations should be prescribed with a view of protecting the water intakes.

"(c) The discharge of garbage and sawmill waste into boundary waters should be prohibited, and industrial and other wastes, which are causing appreciable injury, should be discharged subject to such restrictions as may be prescribed."

## CHANGES IN PERIOD 1913-1949

The pollution problem has been affected by many changes which have taken place in the period from 1913 to 1949. The large increases in population and industrial activities have contributed adversely to the problem. The construction of treatment works for both water and sewage has tended to partially remedy the situation. Continued progress in the sciences of water treatment and of domestic and industrial wastes treatment has provided methods for a more effective solution to this problem.

Comparative populations for the urban areas situated along the boundary waters in 1913 and 1949 are summarized in table 23. Nearly a two-fold increase in population, from 540,000 to 915,000 persons, occurred during this period. The rapid growths of the cities of Buffalo and Niagara Falls, New York, have been primarily responsible for this increase.

Table 23 — POPULATIONS SITUATED ON BOUNDARY WATERS, 1913 AND 1949

| Area | 1913 | | | 1949 | | |
|---|---|---|---|---|---|---|
| | Canada | United States | Total | Canada | United States | Total |
| Lake Erie | - | 15,400 | 15,400 | 1,300 | 38,400 | 39,700 |
| Upper Niagara River | 3,800 | 471,200 | 475,000 | 7,500 | 698,900 | 706,400 |
| Lower Niagara River | 11,000 | 36,700 | 47,700 | 56,600 | 107,000 | 163,600 |
| Lake Ontario | 1,300 | 300 | 1,600 | 1,900 | 1,500 | 3,400 |
| TOTAL | 16,100 | 523,600 | 539,700 | 67,300 | 845,800 | 913,100 |

Although the pollution resulting from industrial wastes was of little or no concern in 1913, it is today a major problem. Vast expansion in industrial activities, particularly along the United States side of the upper Niagara River, has created large volumes and varieties of wastes.

The increasing pollution problem during the 36-year period since 1913 has compelled municipalities to construct sanitary works for water supply protection. All municipalities, with the exception of Fort Erie located near the Niagara River inlet, are using filtered water from the river. Chlorination has been utilized for the disinfection of all municipal supplies. Installations for the treatment of domestic wastes have not kept pace with the extension of sewer services and the treatment of water supplies, but definite progress has been made. The City of Buffalo has installed interceptors and primary treatment facilities serving some 600,000 persons. Eleven other sewage treatment plants have been built in New York at the following places: the cities of Niagara Falls, Lackawanna, and Tonawanda; the villages of Blasdell and Youngstown; the hamlets of Wanakah, Mt. Vernon, and Woodlawn; and the towns (townships) of Grand Island and Tonawanda. On the Canadian side, one plant has been built at Crystal Beach Village, and septic tank installations have been provided at Fort Erie Town, Chippawa Town, and Stamford Township. These plants now serve a total of about 778,000 persons with primary treatment only, and an additional 37,000 persons with secondary treatment. Much of the work on the United States side was financed with Federal aid during the period 1933 to 1940.

Sanitary science has made important contributions toward the solution of pollution problems in this same period. In 1913, the sciences of water purification and sewage treatment were in their initial stages of development. Modern methods of water treatment have become established with widespread usage since that time. Corresponding advances in sewage treatment methods have made possible the adoption of processes capable of producing an effluent of a high degree of purity. The science of industrial waste treatment, while given little thought in 1913, has provided new and improved processes for waste disposal resulting in increased efficiencies for certain industries. However, additional research is needed before similar advances can be attained in the treatment of many of the other industrial wastes.

## EXTENT OF POLLUTION IN 1948-1949

Pollution was found in numerous localities and originating from many sources during the 1949 investigation. The analytical data, resulting from bacteriological, chemical, and physical examinations, are a measure of the extent and effects of various pollutants on these waters used for the purposes already enumerated. The kinds, degree, and locations of pollution are set forth in detail in the two previous chapters. The findings are reviewed and discussed herewith as to their effects on these waters and as related to the questions contained in the terms of the reference.

In the treaty of 1909 between the two countries it was agreed that the waters on either side of the boundary should not be polluted to the injury of health or property on the other side. The first question asked in the present reference to the Commission concerns the transboundary aspect of the pollution problem.

### Transboundary Effects

The data and information presented in chapter VIII have shown clearly that there is a transboundary crossing, both of currents and pollution from either side to the other. This crossing has been demonstrated especially in the lower Niagara River and to a lesser extent in Lake Erie, upper Niagara River, and Lake Ontario. Since waste discharges tend to diffuse and become diluted with the receiving waters or other wastes downstream, it is difficult to trace a specific effluent over the distance required to dissipate its potency. Transboundary currents are largely influenced by such factors as heavy stream flows, ice stoppages, and seiches caused by winds and other varying meteorological conditions. Under these circumstances it is not feasible to state, in exact terms, the amount of pollution which crosses from either side to the other.

## Injury to Health

The danger to health in the use of these waters is measured most readily by the coliform determinations, although constituents of a chemical nature are also of significant importance. Major uses of these waters include domestic and industrial water supply, power, navigation, bathing and recreation. Many of these uses are closely allied to public health and are injuriously affected by the discharge of bacterial and chemical pollutants.

Limits of pollution beyond which a health menace may exist are not universally accepted. Several standards have been formulated from time to time to apply to specific areas and requirements. In the final report on the 1913 investigation the Commission stated that "the standard of purification required of these communities should be such that the streams after receiving their treated sewage would have a mean annual cross-sectional average of B. coli not exceeding 500 per 100 cubic centimeters." A more recent standard for raw water, acceptable for treatment and use as a public water supply, is that recommended by the U. S. Public Health Service in 1946. In this recommendation, water which has an average monthly coliform content of not more than 50 per 100 ml. is acceptable for treatment by simple chlorination alone. Raw water having an average monthly coliform content of not more than 5,000 per 100 ml., and exceeding this number in not more than 20% of the samples examined in any one month, is acceptable for treatment by complete rapid sand filtration and continuous postchlorination. In cases where the coliform bacteria exceed 5,000 per 100 ml. in more than 20% of the samples examined during any one month, and do not exceed 20,000 per 100 ml. in more than 5% of the samples examined during any one month, the waters shall be acceptable when given auxiliary treatment in addition to complete rapid sand filtration and continuous postchlorination. Waters containing coliform bacteria in excess of the above figures are considered unsuitable for use as a source of drinking water supply unless brought into conformance by means of prolonged preliminary storage or some other satisfactory measure. It should be borne in mind that these standards are guides which should be interpreted through the exercise of administrative and technical judgment in the light of specific local conditions.

Since practically all the municipalities in the Lake Erie-Lake Ontario Section obtain their water supplies from the boundary waters, pollution by sewage may affect the entire population if these supplies are not properly purified. Although there have been no typhoid fever outbreaks attributable to public water supplies along the Niagara Frontier in recent years, the effects of water pollution have been manifested in other ways. Advances in water purification in the last 30 years have done much to reduce the menace of water-borne typhoid fever, but sewage contaminated waters can result in outbreaks of gastroenteritis and dysentery. Such an occurrence at Niagara Falls, New York, in 1933 involved approximately 10,000 cases of gastroenteritis. This incident was traced to the municipal water supply which was both filtered and chlorinated. It may be concluded that all sewage pollution must be considered as a potential health hazard.

The relation of coliform pollution in these waters to the standards for public water supplies recommended by the U. S. Public Health Service is a measure of the potential hazard to public health. It was shown in chapter VIII that the major pollution is generally confined within a zone along the United States shore of Lake Erie and along the easterly shore of the upper Niagara River. A lesser degree of pollution exists in the lower river and within an area in Lake Ontario at the river outlet. It was also shown that certain of the municipal water supplies in Lake Erie and in the upper river are particularly affected by polluted water during abnormal stream flow conditions.

In the main body of Lake Erie, the coliform values are within the limits recommended for a water supply protected by chlorination. The supplies of the City of Buffalo and the Town of Fort Erie are using this high quality water although located in the Niagara River inlet. The water along the United States shore, however, is considerably polluted, particularly in the Buffalo harbor area and near the mouths of tributaries. The water in several localities along shore would be considered unsuitable as a drinking supply source. The Western New York Water Company's supply, taken some distance offshore, is considered acceptable from a bacteriological standpoint, although it is at times affected by moderate sewage pollution.

The upper Niagara River receives the heaviest concentration of coliform organisms in the Lake Erie-Lake Ontario Section. As a consequence the quality of the water at many places is unsuitable as a source for potable water supply even when treated by modern purification methods. The westerly portion, including the West Channel, is for the most part acceptable from a bacteriological standpoint if chlorination is provided. The intakes for Tonawanda, North Tonawanda, Lockport, and Niagara Falls No. 1 plant are precariously located in East Channel waters normally beyond the zone of marked pollution but frequently subjected to sporadic heavy pollutional loads. Under these conditions, it is difficult to assure a safe water at all times since rapid changes in the chlorine demand of the raw water may not always be detected, with the result that some polluted water may pass through the treatment plant before adjustments can be made. The Niagara Falls No. 2 plant is supplied from a shore intake located in the zone of heavy pollution. The quality of this supply demands careful and sustained treatment to render it safe for drinking purposes. Plans have been formulated for the abandonment of this supply.

The coliform content of the lower Niagara River is fairly uniform and indicates a quality of water which is acceptable as a source for drinking water if filtration and chlorination, and possibly auxiliary treatment, are provided. The Town of Niagara, Ontario, with an intake near the river outlet, is the only municipal supply taken from the lower river.

There are no water supplies taken from the Lake Ontario area adjacent to the Niagara River. The water varies in quality, being similar to that of the lower river near its outlet and approaching the purity of the main body of Lake Ontario some 10 miles distant from the river outlet.

The presence of sewage pollution in bathing areas constitutes a health hazard. Public bathing facilities are located on the Canadian side of Lake Erie and at the upstream end of Grand Island. Elsewhere, bathing is not extensive as pollution had tended to interfere with the development of suitable areas. There is no statistical evidence to indicate that public health has been injured by pollution of bathing beaches in this section.

## Injury to Property

The discharge of wastes into the boundary waters has interfered with the enjoyment of property rights and has caused injury to property along these waters. Economic losses have been reflected by the higher costs of water purification and in physical destruction or damage to wildlife and watercraft.

The higher costs of water purification in this area can be attributed to pollution by both sewage and industrial wastes. Bacterial pollution has added directly to the cost because more complete treatment is required. Industrial wastes containing taste and odor producing substances, particularly phenols, have created costly control problems in nearly all the municipal supplies. The many problems accompanying the purification of water supplies from intakes located in these polluted waters is prompting the location or extension of the intakes into cleaner water. Such relocation is costly, as evidenced by the $775,000 being spent by Niagara Falls, New York, in extending their No. 1 plant intake into the West Channel. The New York State Department of Health recommends that municipal intakes be located in the better quality water of the West Channel rather than in the waters of the nearer East Channel.

The physical damage imposed by pollution is difficult to evaluate, but nevertheless, is of vital importance. The destruction of both fish and wildfowl, as discussed in chapter VIII is of considerable significance. Industrial wastes containing cyanides, phenols, chlorine, and copper and iron salts have been implicated in causing many of the fish kills in the upper river. Oil pollution has at times caused widespread destruction of birds in these waters. Such situations, if continued, would do much to interfere with normal sports activities, which are an important asset to any watercourse. Wastes containing oils, greases, and tars coat the hulls of boats and docks and may constitute a potential fire hazard.

Aside from these evidences of property damage, mention should be made of the aesthetic value accorded to the Niagara River. The scenic resources afforded by both the Falls and the Niagara River are of considerable importance to the economics of the Niagara Frontier area. The promiscuous discharge of such deleterious materials as refuse, oils, or other obnoxious wastes would greatly detract from the appearance of these boundary waters.

## SOURCES OF POLLUTION

Pollution in these waters is principally due to the disposal of domestic sewage and industrial wastes. These wastes are discharged either through municipal sewer systems or through separate industrial outlets to the boundary waters and their tributaries. Wastes are discharged throughout the entire section of these waters, although there are several areas in which the primary sources of pollution are concentrated.

### Sources of Domestic Wastes

The municipalities chiefly contributing domestic sewage to the boundary waters are listed in table 11 of chapter VII. All of the large municipalities in this section are sewered, and a majority have sewage treatment plants.

In Lake Erie the major sources of pollution are located along the United States side. The sewered population of 30,000 persons at Lackawanna, immediately south of Buffalo, constitutes about three-fourths of the total sewered population along Lake Erie. Several small villages located farther south along the lake shore and Crystal Beach Village on the Canadian side also discharge sewage into the lake area. The sewage from all these municipalities is subjected to some degree of treatment.

Along the upper Niagara River, the City of Buffalo, with about 600,000 persons, represents nearly 70% of the total sewered population in the Lake Erie-Lake Ontario Section. Nearly all of the city's sewage receives primary treatment, except for intermittent discharges of raw sewage during storm periods. A total of 50 storm water overflows discharge excess storm water which contains some raw sewage. The majority of these overflows discharge into the Buffalo River, the remainder discharging into the harbor area and the Niagara River. Other principal sources along the United States side of the upper river are in the Tonawanda area. The Town (township) of Tonawanda, immediately north of Buffalo, discharges treated sewage from a population of 36,000 persons into two small streams tributary to the East Channel. The City of Tonawanda, with a sewered population of 15,000, is provided with a primary treatment plant and three storm water overflows discharging to the East Channel. Raw sewage from the City of North Tonawanda with a sewered population of 27,000 enters the East Channel through five shore outfalls. The Town of Fort Erie with a population of 7,500 is the only municipality on the Canadian side disposing of sewage into the upper river.

Domestic sewage enters the lower Niagara River within the section of rapids extending some six miles downstream from the Falls. The City of Niagara Falls with a sewered population of about 105,000 persons is the only source of sewage on the United States side. The sewage is subjected to fine screening, supplemented by chlorination during the summer months, except for intermittent discharges from the city's eight overflow sewers. On the Canadian side, raw sewage from the City of Niagara Falls, with a population of 22,000 persons, is discharged into the river. The discharge from the H.E.P.C. power canal contains the domestic wastes from some 26,000 persons located upstream.

In the Lake Erie-Lake Ontario Section, the present survey showed a daily discharge of 228 million U. S. (190 Imp.) gallons of municipal wastes. About 210 million U. S. (175 Imp.) of this amount receives some degree of treatment. In many cases, however, this treatment is not adequate. With one exception, storm water overflows are not treated.

Sources of Industrial Wastes

Information on industrial waste discharges in the Lake Erie-Lake Ontario Section, showing distribution by areas, has been given in table 15 in chapter VII. This table reveals that the heaviest waste concentrations are discharged along the United States shores of Lake Erie and the Niagara River, and along their tributaries. Little pollution was shown to occur along the Canadian shore of the Niagara River, with the exception of wastes reaching the Welland River and entering the lower Niagara River by way of the H.E.P.C. power canal. No industrial pollution enters Lake Ontario directly.

A total of about 500 million U. S. (420 Imp.) gallons of industrial wastes, or nearly twice that of the municipal wastes, is discharged daily. This volume includes condenser and cooling water as well as process wastes. Of this amount about 30% is discharged to Lake Erie on the United States side and 60% to the United States side of the Niagara River.

The daily discharge of the more significant polluting substances in these wastes was found to be: 6,340 pounds of phenol, 1,755 pounds of cyanides, 10,565 pounds of ammonium compounds, 1,890 U. S. (1,575 Imp.)

gallons of oil, 757,130 pounds of suspended solids, and organic matter having a biochemical oxygen demand of over 96,000 pounds.

## Sources of Other Wastes

In addition to municipal and industrial effluents, these waters receive wastes from dredging, navigation, and careless dumping of refuse. Reference has been made in chapter VII as to the nature and extent of these practices.

Dredged material from the Buffalo area is deposited in dumping grounds located in Lake Erie near the mouth of Smokes Creek, while material from the Niagara River is deposited near the downstream end of Grand Island. Substantial amounts of polluting substances are transferred in this way to normally clean waters.

Pollution contributed by vessels is most significant in the Buffalo harbor area. Many freight and several large passenger ships operate into the port of Buffalo. These contribute bacterial wastes in the form of sewage and refuse, and oil wastes found in bilge and ballast waters.

The widespread dumping of garbage or other refuse into these waters is not ordinarily practiced, although this did occur recently at the City of Niagara Falls, New York, over a period of several weeks until corrective measures were taken. Dumping of such material causes unsightly appearances.

## REMEDIAL MEASURES

It has been shown that serious pollution exists in the Lake Erie-Lake Ontario Section of the boundary waters. The terms of reference require information on measures necessary for remedying the situation.

Such measures must raise the quality of the water to the point where they will be satisfactory for domestic and other uses.

## Objectives for Boundary Waters Quality Control

Remedial measures involve the treatment or control of all sources of pollution reaching the boundary waters and their tributaries. Information acquired during the investigation enables the Technical Advisory Board to prepare "Objectives for Boundary Waters Quality Control."

The formulation of water quality objectives is essential for defining the remedial measures necessary for abating pollution. Objectives may be established in two ways: (1) through limitation of the quantity of deleterious substances allowed to enter the receiving streams, or (2) through limitation of these substances within the receiving waters. Whichever type of objective is used, the end result must be the same, namely, maintenance of the water in a condition suitable for all subsequent uses.

Objectives adopted for boundary waters quality control establish the ultimate aim of corrective measures. Such objectives must be outlined if stream pollution abatement is to be successful and impartial. Each water use requires a specific quality of water, and in the majority of cases, the uses of a watercourse are varied. Therefore, the complex interrelationships of these uses must be considered when establishing objectives. An effort has been made to adhere to these principles in the formulation of the following objectives:

## OBJECTIVES FOR BOUNDARY WATERS QUALITY CONTROL

The term "boundary waters" as herein used shall include the waters defined in the amended reference to the International Joint Commission dated April 2, 1948, and is as follows:

Niagara River from Lake Erie to Lake Ontario

These objectives are for the boundary waters in general, and it is anticipated that in certain specific instances, influenced by local conditions, more stringent requirements may be found necessary.

### GENERAL OBJECTIVES

All wastes, including sanitary sewage, storm water, and industrial effluents, shall be in such condition when discharged into any stream that they will not create conditions in the boundary waters which will adversely affect the use of these waters for the following purposes: source of domestic water supply or industrial water supply, navigation, fish and wildlife, bathing, recreation, agriculture and other riparian activities.

In general, adverse conditions are caused by:

(A) Excessive bacterial, physical or chemical contamination.

(B) Unnatural deposits in the stream, interfering with navigation, fish and wildlife, bathing, recreation, or destruction of aesthetic values.

(C) Toxic substances and materials imparting objectionable tastes and odors to waters used for domestic or industrial purposes.

(D) Floating materials, including oils, grease, garbage, sewage solids, or other refuse.

### SPECIFIC OBJECTIVES

In more specific terms, adequate controls of pollution will necessitate the following objectives for:

(A) Sanitary Sewage, Storm Water, and Wastes from Watercraft

Sufficient treatment for adequate removal or reduction of solids, bacteria and chemical constituents which may interfere unreasonably with the use of these waters for the purposes afore-mentioned.

Adequate protection for these waters, except in certain specific instances influenced by local conditions, should be provided if the coliform M.P.N. median value does not exceed 2,400 per 100 ml. at any point in the waters following initial dilution.

## (B) Industrial Wastes

### (1) Chemical Wastes - Phenolic Type

Industrial waste effluents from phenolic hydrocarbon and other chemical plants will cause objectionable tastes or odors in drinking or industrial water supplies and may taint the flesh of fish.

Adequate protection should be provided for these waters if the concentration of phenol or phenolic equivalents does not exceed an average of 2 p.p.b. and a maximum of 5 p.p.b. at any point in these waters following initial dilution. This quality in the receiving waters will probably be attained if plant effluents are limited to 20 p.p.b. of phenol or phenolic equivalents.

Some of the industries producing phenolic wastes are: coke, synthetic resin, oil refining, petroleum cracking, tar, road oil, creosoting, wood distillation, and dye manufacturing plants.

### (2) Chemical Wastes, other than Phenolic

Adequate protection should be provided if:

(a) The pH of these waters following initial dilution is not less than 6.7 nor more than 8.5. This quality in the receiving waters will probably be attained if plant effluents are adjusted to a pH value within the range of 5.5 and 10.6.

(b) The iron content of these waters following initial dilution does not exceed 0.3 p.p.m. This quality in the receiving waters will probably be attained if plant effluents are limited to 17 p.p.m. of iron in terms of Fe.

(c) The odor-producing substances in the effluent are reduced to a point that following initial dilution with these waters the mixture does not have a threshold odor number in excess of 8 due to such added material.

(d) Unnatural color and turbidity of the wastes are reduced to a point that these waters will not be offensive in appearance or otherwise unattractive for the afore-mentioned uses.

(e) Oil and floating solids are reduced to a point such that they will not create fire hazards, coat hulls of water craft, injure fish or wildlife or their habitat, or will adversely affect public or private recreational development or other legitimate shore line developments or uses. Protection should be provided for these waters if plant effluents or storm water discharges from premises do not contain oils, as determined by extraction, in excess of 15 p.p.m., or a sufficient amount to create more than a faint irridescence.

Some of the industries producing chemical wastes other than phenolic are: oil wells and petroleum refineries, gasoline filling stations and bulk stations, styrene co-polymer, synthetic pharmaceutical, synthetic fibre, iron and steel, alkali chemical, rubber fabricating, dye manufacturing, and acid manufacturing plants.

(3) Highly Toxic Wastes

Adequate protection should be provided for these waters if substances highly toxic to human, fish, aquatic, or wildlife are eliminated or reduced to safe limits.

Some of the industries producing highly toxic wastes are: metal plating and finishing plants discharging cyanides, chromium or other toxic wastes; chemical and pharmaceutical plants and coke ovens. Wastes containing toxic concentrations of free halogens are included in this category.

(4) Deoxygenating Wastes

Adequate protection of these waters should result if sufficient treatment is provided for the substantial removal of solids, bacteria, chemical constituents and other substances capable of reducing the dissolved oxygen content of these waters unreasonably. Some of the industries producing these wastes are: tanneries, glue and gelatin plants, alcohol, including breweries and distilleries, wool scouring, pulp and paper, food processing plants such as meat packing and dairy plants, corn products, beet sugar, fish processing and dehydration plants.

Note: The methods of determination of the chemical constituents referred to in the preceding objectives are as given in "Analytical Methods for Boundary Waters Quality Control," as prepared by the Board of Technical Advisers. Bacterial determinations are to include the presumptive and confirmed tests for the coliform group of bacteria as given in "Standard Methods for the Examination of Water and Sewage," 9th Edition.

## Hearings Before the Commission

Public hearings for municipalities, industries, and all other interested parties were held by the International Joint Commission in Buffalo on November 15 and 16, and December 13, 14, and 15, 1949, and at Niagara Falls, Ontario, on November 17, 1949. The purpose of these hearings was to obtain information on waste treatment processes now in use or proposed, cost estimates of remedial measures, time required to carry out these measures, and comments on the application of the objectives to specific wastes. The principal points developed at the hearings were as follows:

(a) The evidence brought out at the hearings indicates that the pollution affecting municipal water supplies is due both to industrial wastes and domestic sewage.

(b) Pollution in boundary waters has resulted in the serious destruction of wildfowl, fish and other aquatic life.

(c) In the past, pollution from the Niagara River has extended eastward along the southern shore of Lake Ontario affecting water intakes. However, no such difficulty has been recorded in the past 10 years.

(d) Plans of industries for dealing with their waste problems indicate that most of the industries take their responsibilities seriously for keeping deleterious wastes out of boundary waters, and are making plans or have completed works for treatment of their wastes.

(e) Plans for collecting and treating municipal wastes as well as extending existing facilities are in preparation by certain municipalities.

(f) Municipalities are relatively inactive at the present time insofar as the construction of works for treating sewage is concerned. Boundary waters are being denied the benefits of municipal pollution control by the limited ability of some communities to finance treatment works.

(g) The need for promptly providing funds to construct necessary municipal sewage treatment works has been shown.

(h) The people living near the boundary waters have been thwarted in their efforts to make recreational use of boundary waters because of pollution.

(i) To protect recreational investments and to permit present and future industries to have access to reasonably clean waters for industrial purposes, it is necessary to curb the tendency toward increased pollution of boundary waters and to eliminate much of the pollution now being added to these waters.

(j) Municipalities and industries represented at the hearings were in general agreement with the "Objectives for Boundary Waters Quality Control."

(k) Evidence was presented that the International Joint Commission should maintain a continuing interest in the condition of these boundary waters, and that an effective way should be found in which to exercise such interest.

## Pollution Control Program

It is apparent from the data presented in the foregoing, that a comprehensive waste treatment program is required. Two methods for dealing with water pollution problems are commonly advocated. One viewpoint stresses the utilization of the stream for carrying away as much waste as it can tolerate without interfering too seriously with normal stream uses. The other would exclude all impurities from watercourses. Between these conflicting views is a course which the Advisory Board feels will meet the situation. This course has been followed in developing the "Objectives for Boundary Waters Quality Control." No tolerance limit, whether for the effluent or for the stream, can be expected to remain fixed. It must change with changing conditions and each change should be in the public interest.

The large volume of water flowing between the United States and Canada should be regarded as a natural resource to be shared by both countries. It should not be wantonly destroyed by pollution, either from municipalities, from industries, or any other source. An intelligent policy of safeguarding these waters from gross pollution should be fostered and encouraged so that they will be used for the highest public good and not exploited by selfish interests.

The pollution problem must be considered not only on the basis of present-day conditions but also in terms of the future. Facilities for the treatment of municipal sewage must incorporate sufficient flexibility to permit ready expansion to satisfy future demands. Industrial waste disposal programs must not only provide adequate treatment for the present,

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but they must ensure that new industries or new industrial processes which may be established will not jeopardize the rights of users of these waters. Industry must continue to assume, in cooperation with other agencies, the research and planning required for satisfactory and efficient disposal of industrial wastes.

## Disposal of Municipal Wastes

Since municipal sewage carries the organisms of diseases transmissible to humans, its disposal into the boundary waters creates a major problem. The heavy bacterial load placed on these waters is indicated by a sewage discharge totaling 228 million U. S. (190 Imp.) gallons per day. This flow represents a contributing population of nearly 900,000 persons. About 90% of the sewage receives some degree of treatment, but in practically all cases only primary treatment is utilized.

The coliform content of the boundary waters found during the present investigation showed a reduction from that found during the 1913 survey. In 1913 raw sewage from a population of nearly 540,000 persons was disposed of into these waters. In the final report of that investigation, it was recommended that the sewage be treated either by fine screening or sedimentation and, when necessary, by chemical disinfection in order to secure in the receiving waters a mean annual cross-sectional average B. coli of 500 per 100 cubic centimeters. Despite the fact that the population situated along the boundary waters has almost doubled since 1913, the construction of sewage treatment plants has resulted in a reduction in the over-all bacterial pollution.

Even though bacteriological conditions in these waters have improved during recent years, the present investigation reveals that further improvement is necessary. Primary treatment of sewage has been provided in a number of plants, but many municipalities discharge raw or inadequately treated sewage. It is obvious that, as a first step, effective primary treatment of sewage from all communities, by sedimentation and disinfection of the effluents, should be undertaken immediately.

It is the opinion of the Advisory Board that the question of a further degree of treatment will depend on a number of factors. Local conditions at any place on either side of the boundary may give emphasis to the need for more complete treatment. Major population growth, industrial expansion, or changes affecting the hydraulic regimen of the river may precipitate conditions in the future which will materially alter the requirements of treatment necessary to meet the objectives for boundary waters quality control. It is not possible to predict these situations now with any degree of accuracy. It is recognized that regardless of the extent of treatment of sewage and industrial wastes, municipalities along the upper river will find it preferable to extend their water intakes beyond the zone of stratification carrying these treated wastes. Treatment and points of disposal should be such to ensure against adversely affecting the water at these extended intakes or placing an undue loading on water plants in the lower river where the effects of stratification are lost in the more complete mixing and dilution across the width of the river.

Storm water overflows from combined sewers should be considered in conjunction with programs for treatment of sewage and industrial wastes. These storm flows may discharge large quantities of wastes in times of heavy run-off and thereby create adverse conditions. Generally effective protection can be ensured by the use of adequate retention in sedimentation tanks followed by disinfection, by storage in enlarged interceptor sewers, or by any other means.

Failure to provide adequate capacity, or the misuse, or the neglect of treatment facilities must be avoided. Inefficient operation of a plant or unwarranted bypassing of untreated or partially treated sewage must not be permitted.

The Board of Technical Advisers is of the opinion that reasonable stream sanitation consistent with the wide variety of uses of these waters, both present and future, will be maintained if the wastes are treated to a degree which will result in a median coliform M.P.N. value not exceeding 2,400 per 100 ml. at any point in the boundary waters following initial dilution of waste discharges. It will likewise be necessary to provide sufficient treatment of other substances, as defined in the objectives, which may injuriously affect the water.

## Disposal of Industrial Wastes

The volume of industrial wastes discharged directly into these waters, exclusive of that carried in municipal sewers, is 500 million U. S. (420 Imp.) gallons per day, or twice that of municipal sewage. As shown in table 15, chapter VII, large quantities of deleterious substances are carried in these wastes, seriously affecting the quality of the receiving waters and causing injury to health and property.

Industrial wastes, in contrast to domestic sewage, are so varied in composition that uniform treatment processes are not applicable. Each waste must be considered individually in the light of the deleterious substances present. Certain of these substances are of particular significance in these waters, and their limits of tolerance are included in the objectives for boundary waters quality control. The problem of industrial waste treatment must remain the responsibility of the industry involved.

One of the serious problems of industrial waste disposal is that of sudden or concentrated discharges, commonly known as "slugs" or "spills". These constitute the release of a volume of highly concentrated polluting material over a short period of time. Such discharges are intermittent, but their effects may extend for great distances and for prolonged periods. It is the obligation of industry to avoid slugs and spills. Retention tanks or lagoons should be provided where such conditions may occur, so that the discharge will be at a uniform rate.

## Buffalo River Pollution Abatement Program

The slug-type releases from the Buffalo River and harbor area into the Niagara River are of even greater significance than the sudden discharges from individual industries. The hydraulic features of this highly industrialized area, as discussed in chapter IV, are such that pollutants become increasingly concentrated during periods of low flow in the Buffalo River and may subsequently be discharged as a slug during high river flows. Such slugs seriously affect the quality of the water in the Niagara River. Since operators of water purification plants are not aware of the approach of these slugs, some polluted water may pass through the water plant before treatment can be adjusted to produce a safe water.

The gross pollution of Buffalo River during low flow periods has created other problems. The concentration of pollutants in the river makes it unsuitable for an industrial supply. This situation prompted a comprehensive investigation and analyses of industrial wastes of five major industries located on the Buffalo River. The investigation was undertaken in 1946 jointly by the technical representatives of industry, the Buffalo Sewer Authority, and the state departments of health and conservation. A program for reduction of pollution was agreed upon. This provided for approximately 50% reduction of the organic pollution load (B.O.D.) then existing and the elimination of toxic and acid waste discharges from these industries. In addition and as a component part of the program, a plan known as the Lake Erie Cooling Water Project was agreed upon, which provides that these industries participate in pumping 120 to 180 M.G.D. (U. S.) of water from Lake Erie for industrial and cooling purposes. This would have the additional benefit of providing water to the Buffalo River at times of low flow. The benefits to the industries concerned may be summarized as follows: the project should provide cooler water and thereby more efficient cooling operations, eliminate the corrosion of cooling equipment and piping, eliminate the need for liming to neutralize acid wastes, eliminate the deposition of suspended solids in the plants, and provide approximately one-third of the oxygen demand of the industrial wastes. It should be noted that this diluting water will not reduce the pollution added to the Buffalo River, but by augmenting the low river flow it should reduce the concentration of pollutants in the river and thereby minimize the hazard of slug discharges to the Niagara River.

## Disposal of Other Wastes

Other wastes originate chiefly from dredging, navigation, and refuse disposal. While these wastes are of secondary importance, they contribute to the pollution of these boundary waters.

Dredging operations transfer substantial amounts of polluting substances into normally clean waters. The dumping grounds for this material should be selected so as not to interfere with legitimate water uses, or result in the transboundary travel of the dumped material.

Vessels add pollution by their discharge of sewage, bilge water, and ballast water. Bacterial pollution can be corrected by the use of sewage retention tanks, accompanied by some form of disinfection, which tanks can then be emptied either to shore treatment facilities or overboard into nonrestricted areas. Oil pollution from bilge and ballast waters can be reduced by the installation of oil separators.

The disposal of garbage and other refuse into these waters would greatly detract from their scenic value. Boats should provide facilities for storing this material for subsequent disposal on land. Dumping from shore by municipalities or careless persons should be controlled by state or provincial, or local agencies.

## PROGRESS IN POLLUTION CONTROL

Much of the progress in the treatment of municipal wastes disposed into these waters was accomplished during the late 1930's. During that period, the cities of Buffalo, Tonawanda, and Niagara Falls, New York, constructed sewage treatment works at an expenditure of about $20,000,000. While no treatment plants have been constructed following 1940, several municipalities have been active since the war in preparing plans for the initiation of projects in the future.

Substantial progress in the control or elimination of industrial pollution has been accomplished during the 5-year period since termination of the war. Several factors have been responsible, such as availability of materials, stimulation by state and provincial authorities and interest of sportsmen's organizations, research on waste disposal methods, and the activities associated with this investigation. At the time of the hearings in 1949 it was estimated that industry had spent about $5,000,000 in the past five years and was contemplating expenditures totaling nearly $2,000,000 for further corrective measures.

### Present Status of Municipal Waste Treatment

The present status of waste treatment programs for the New York municipalities situated along the boundary waters is as follows:

| Municipality | Present Status |
|---|---|
| **Lake Erie Area** | |
| Town of Hamburg | |
| Wanakah Sewer District | Primary treatment with chlorination of effluent. No plans for plant expansion. |
| Mt. Vernon Sewer District | Primary treatment with chlorination of effluent. No plans for plant expansion. |
| Woodlawn Sewer District | Primary and secondary treatment with chlorination of effluent. No plans for plant expansion. |
| Blasdell Village | Primary and secondary treatment without chlorination of effluent. Construction under way for a new treatment plant to provide primary and secondary treatment for sewage from new Bethlehem Steel Company plant, Ford Motor Company plant, and two subdivisions as well as Blasdell. Plant scheduled for completion December 1950. |
| Lackawanna City | Primary and secondary treatment with chlorination of effluent. Plans have been approved for additional sludge handling facilities, but construction delayed. |
| **Niagara River Area** | |
| Buffalo City | Primary Treatment with chlorination of effluent. Plans for enlarging certain units under consideration. |
| Town of Grand Island | |
| Sewer District No. 1 | Primary treatment with chlorination of influent. Plans for plant expansion under way. |
| Sewer District No. 2 | Plans under way for a primary treatment plant with chlorination of effluent to serve another small portion of the town known as Sandy Beach. |
| Tonawanda City | Primary treatment with chlorination of effluent. No plans for plant expansion. |

| Municipality | Present Status |
|---|---|
| North Tonawanda City | No treatment. Construction plans for interceptors and primary treatment with chlorination of the effluent are approved. Construction will be over a five-year period. |
| Town of Tonawanda | |
| Sewer District No. 2 | Primary treatment with chlorination of the effluent. No plans for expansion. |
| Sewer District No. 3 | Primary and secondary treatment without chlorination of effluent. No plans for expansion. |
| Niagara Falls City | Fine screening plant, with chlorination of effluent during summer season. Studies under way to determine possibility of remodeling plant for sedimentation. |
| Lewiston Village | No municipal sewers. Plans for sewers and primary treatment approved, but construction not imminent. |

### Lake Ontario Area

| | |
|---|---|
| Youngstown Village | Primary treatment with chlorination of effluent. No plans for expansion. |

In Ontario, the present status of the sewerage programs for the boundary municipalities is as follows:

### Lake Erie Area

| | |
|---|---|
| Crystal Beach Village | Primary and secondary treatment with chlorination of the effluent. Plans under consideration to provide further primary treatment for peak summer loads. |

### Niagara River Area

| | |
|---|---|
| Fort Erie Town | Septic tank treatment without chlorination of effluent. Plans under consideration for treatment plant. |

| Municipality | Present Status |
|---|---|
| Chippawa Village | Septic tank treatment without chlorination of effluent. No plans for further treatment plant under consideration. |
| Niagara Falls City | No treatment. Plans for treatment plant under consideration. |
| Stamford Township | Septic tank treatment for half of sewage. No treatment for remainder. No plans for treatment under consideration. |
| Welland City | No treatment. Preliminary studies under consideration. |
| Queenston Village | No municipal sewers. No plans for sewers or treatment works. |
| Niagara Town | No treatment. No plans for treatment works. |

### Present Status of Industrial Waste Treatment

The status of industrial waste treatment programs on each side of the boundary is presented below. This status is indicated by key numbers as shown. Where an industry provides treatment prior to waste discharge to the municipal sewer system, the key number (3) precedes those key numbers that apply to the status of waste treatment provided by the industry.

(1) Control measures provided.

(2) Control measures provided. Adequacy not demonstrated.

(3) Municipal sewerage facilities utilized.

(4) Actual construction under way.

(5) Studies and plans under way.

(6) No progress indicated.

In New York, the status of the industries is as follows:

| Industry | Status |
|---|---|
| Allegheny Ludlum Steel Corporation | |
| Sewage | (6) |

| Industry | Status |
|---|---|
| Bethlehem Steel Company | |
| Acid waste | (5) |
| Cyanide waste | (1) |
| Oil waste | (5) |
| Phenol waste | (1) |
| Solids | (4) |
| Sewage | (6) |
| Carborundum Company | |
| Solids | (6) |
| Sewage | (3) |
| Chevrolet-Tonawanda, Division of General Motors Corporation | |
| Oil wastes | (5) |
| Sewage | (1) |
| Donner-Hanna Coke Corporation | |
| Cyanide waste | (6) |
| Phenol waste | (5) |
| Sewage | (3) |
| Dunlop Tire and Rubber Corporation | |
| Industrial waste | (1) |
| Sewage | (1) |
| E. I. du Pont de Nemours & Company, Inc. Electrochemicals Department | |
| Industrial waste | (3) |
| Sewage | (3) |
| E. I. du Pont de Nemours & Company, Inc. Rayon Division | |
| Industrial wastes | (2) |
| Sewage | (1) |
| Durez Plastics & Chemicals, Inc. | |
| Phenol wastes | (3), (2), and (5) |
| Sewage | (3) |
| Electro Metallurgical Division, Unit of Union Carbide & Carbon Corporation | |
| Solids | (2) |
| Sewage | (3) |
| Frontier Oil Refining Corporation | |
| Oil wastes | (2) |
| Sewage | (1) |

| Industry | Status |
|---|---|
| General Chemical Division, Allied Chemical & Dye Corporation | |
| Acid wastes | (1) |
| Sewage | (3) |
| Hooker Electrochemical Company | |
| Industrial wastes | (3) |
| Sewage | (3) |
| International Paper Company, Niagara Falls Plant | |
| Industrial wastes | (2) |
| Sewage | (3) |
| International Paper Company, Tonawanda Plant | |
| Industrial wastes | (2) |
| Sewage | (6) |
| Iroquois Gas Corporation, Subsidiary of National Fuel Corporation, Bradley Street Plant | |
| Industrial wastes | (3) and (2) |
| Sewage | (3) |
| Iroquois Gas Corporation, Subsidiary of National Fuel Corporation, Mineral Springs Road Plant | |
| Industrial wastes | (3) and (6) |
| Sewage | (3) |
| Kimberly-Clark Corporation | |
| Industrial wastes | (3) |
| Sewage | (3) |
| Mathieson Chemical Corporation | |
| Industrial wastes | (3), (2), and (5) |
| Sewage | (3) |
| National Aniline Division, Allied Chemical & Dye Corporation | |
| Industrial wastes | (2) and (5) |
| Sewage | (3) |
| Niacet Chemicals Division, United States Vanadium Corporation, Unit of Union Carbide & Carbon Corporation | |
| Industrial wastes | (3) |
| Sewage | (3) |

| Industry | Status |
|---|---|
| Niagara Alkali Company | |
| Industrial wastes | (3), (1), and (5) |
| Sewage | (3) |
| Oldbury Electro-Chemical Company | |
| Industrial wastes | (3) and (1) |
| Sewage | (3) |
| Republic Steel Corporation | |
| Acid wastes | (2) |
| Oil wastes | (5) |
| Solids | (2) |
| Sewage | (3) |
| Semet-Solvay Division, Allied Chemical & Dye Corporation | |
| Cyanide wastes | (6) |
| Phenol wastes | (6) |
| Sewage | (2) |
| Socony-Vacuum Oil Company, Inc. | |
| Industrial wastes | (2) and (5) |
| Sewage | (3) |
| Spaulding Fibre Company, Inc. | |
| Phenol wastes | (5) |
| Sewage | (3) |
| Tonawanda Boxboards Division, Robert Gair Company, Inc. | |
| Industrial wastes | (1) |
| Sewage | (3) |
| Van Raalte Company, Inc. | |
| Industrial wastes | (3) |
| Sewage | (3) |
| Wickwire Spencer Steel Division, Colorado Fuel & Iron Corporation | |
| Acid wastes | (1) |
| Oil wastes | (5) |
| Solids | (5) |
| Sewage | (1) |

In Ontario, the present status of industrial waste treatment programs is summarized as follows:

| Industry | Status |
|---|---|
| North American Cyanamid Limited, Welland Works | |
| Cyanide wastes | (2) |
| Ammonium wastes | (2) |
| Solids | (2) |
| North American Cyanamid Limited, Niagara Falls Plant | |
| Solids | (5) |
| Norton Company | |
| Solids | (3) |
| Canadian Carborundum Company | |
| Solids | (3) |

COSTS AND FINANCING

The following cost estimates for remedial measures have been prepared in answer to the question in the reference. The municipal costs are given for primary treatment including the required intercepting sewers. For industries, the costs are estimated on the basis of compliance with the objectives for boundary waters quality control. The cost of the Lake Erie Cooling Water Project is also shown, inasmuch as it would substantially reduce heavy slugs of pollution in the Niagara River.

Costs for Municipalities (interceptors and primary treatment)

| | |
|---|---|
| United States side | $ 7,250,000 |
| Canadian side | 2,250,000 |
| Total Municipal | $ 9,500,000 |

| | | |
|---|---|---|
| **Costs for Industries** | | |
| United States side | $ 4,000,000 | |
| Canadian side | 100,000 | |
| Total Industrial | $ 4,100,000 | |
| Lake Erie Cooling Water Project | $ 5,500,000 | |
| GRAND TOTAL | | $ 19,100,000 |

A major difficulty in the solution of water pollution problems has been the reluctance of municipalities and industry to make funds available for this purpose. This may be due either to financial inability, lack of responsibility by the polluter, or indifference on the part of the public. Accordingly, it is important to consider methods of securing funds for the construction and operation of remedial works.

Remedial works for treating municipal wastes must be constructed through public funds. These may come from any of several sources such as cash reserves, short term loans or debentures, general obligation bonds, special assessment bonds, revenue bonds, government aid, or any combination of these. The annual payments on capital debts incurred by the municipalities for such works and for their operation may come from general taxation or some form of service charge. Since the sewage works are designed for the benefit of the entire community and are an obligation of the municipality, some municipal authorities favor paying part of the costs by general taxes. In order to apportion the remaining costs on the basis of benefits derived the practice of applying a service charge is gaining widespread use. These service charges are designated by several names such as sewer rates, sewage service rates, sewer rentals, and others. These rates have advantages which justify serious study by public officials confronted with the problem of financing municipal sewage treatment works.

It is a recognized fact that the correction of industrial waste pollution is the responsibility of the industry. Experience has demonstrated that in certain industries it is possible to reclaim from the wastes useful by-products which offset the cost of disposal, or to modify processes in an effort to reduce wastes. The treatment or control of these wastes, however, whether profitable or otherwise, must be regarded as a part of the cost of production.

## LEGISLATION ON POLLUTION CONTROL

Legislation applicable to water pollution control in this section of the boundary waters was reviewed in chapter V. It defines federal, state and provincial, and municipal responsibilities and jurisdictions.

Federal legislation in the United States centers about Public Law 845, passed in 1948, and known as the "Water Pollution Control Act." It was designed "to provide Federal technical services to State and interstate agencies and to industries, and financial aid to State and interstate agencies and to municipalities in the formulation and execution of their stream pollution abatement programs." There is also Federal legislation applicable to certain types of pollution entering harbors and other navigable waters.

In Canada there is no Federal legislation which is concerned with pollution of water per se. There are, however, certain statutes which indirectly deal with this problem, particularly as applied to navigation, fisheries and wildlife.

In the State of New York, pollution control is centered in Article VI of the Public Health Law. A Water Pollution Control Board, created by this new law, has full authority to deal with all types of pollution.

In the Province of Ontario legislation applicable to pollution control is contained in the Public Health Act and other enactments.

Municipalities are authorized to enact regulations or by-laws dealing with such local matters as control of pollution, restrictions on the use of sewers, setting sewer service rates, and financing.

## THE CONTINUING PROGRAM

It is recognized that the control of pollution in these waters is an ever changing problem. The rapidly increasing population and industrial activity in this area and projected hydraulic developments will necessitate continual supervision of the pollution control program. The adequacy of any new treatment works for both sewage and industrial wastes must be demonstrated. Technical difficulties are anticipated in connection with certain industrial wastes where further development of treatment measures is required.

A spirit of cooperation has been evident, particularly among industries. Such cooperation has also been shown by the municipalities, but it has been less productive largely because of financial difficulties. Many large industrial concerns are undertaking their own pollution research and abatement programs on a national scale. Other industries have formed into groups or associations primarily for the development of waste treatment methods. Such groups include the Manufacturing Chemists Association of the United States, the American Petroleum Institute, the National Council for Stream

Improvement (of the Pulp, Paper and Paperboard Industries) Incorporated, The American Iron and Steel Institute, and many others.

Past experience has shown that constant effort and attention by regulatory authorities is needed if existing pollution is controlled and new pollution is to be prevented. It is believed advisable for the Commission to foster pollution abatement programs for the boundary waters through consultation and cooperation with Federal, State and Provincial governments. The administration of such a program should be carried on through existing pollution abatement authorities. Progress in this work will be aided if a committee be established to maintain a continuing interest in the pollution problem. Such a committee would supplement and strengthen the efforts made by local authorities and would permit the interchange of reports on progress. This committee should consist of representatives from the Federal, State and Provincial governments involved in this problem.

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